A28

The Kent Incorporated Society for Promoting Experiments in Horticulture

IMPERIAL MYCOLOGICAL INSTITUTE
17 DEC 1945

ANNUAL REPORT

(THIRTY-SECOND YEAR)

1944

EAST MALLING RESEARCH STATION

Near MAIDSTONE

KENT

1st January, 1944 to 31st December, 1944

Free to Associate Members
Price to Non-Members:—
5/- post free
Great Britain only

Published
November, 1945

THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

ANNUAL REPORT

(THIRTY-SECOND YEAR)

1944

EAST MALLING
RESEARCH STATION

Near MAIDSTONE

KENT

1st January, 1944, to 31st December, 1944

Published November, 1945

PRINTED IN GREAT BRITAIN BY HEADLEY BROTHERS
109 KINGSWAY, LONDON, W.C.2 ; AND ASHFORD, KENT

CONTENTS

PAGE

GOVERNING MEMBERS OF THE SOCIETY 5
MEMBERS OF THE EXECUTIVE COMMITTEE 6
STAFF 7
THE IMPERIAL BUREAU OF HORTICULTURE AND PLANTATION CROPS 8
EDITORIAL 9
JESSE AMOS—AN APPRECIATION 11

Section I

THE EXPERIMENTAL FARM

EXPERIMENTAL ORCHARDS—TOP FRUITS 13
SMALL FRUITS 13
EXPERIMENTAL NURSERIES 13
OUTDOOR TOMATOES 14
ARABLE CROPS 14
HOPS 15
ROUTINE SPRAYING PROGRAMME 15

Section II

GENERAL REVIEW OF RESEARCH WORK, WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY 17
II. STATISTICS AND RECORDS 22
III. PLANT PHYSIOLOGY 23
IV. BIOCHEMISTRY 24
V. PLANT PATHOLOGY 26
VI. ENTOMOLOGY 28
VII. PLANT PROTECTIVE CHEMISTRY 29
VIII. HOPS 30
IX. TECHNICAL SECTION 33

Section III

RESEARCH REPORTS

POMOLOGY

A Note on the Use of Synthetic Growth Substances on Plum Rootstock Layer Beds. R. J. GARNER and E. S. J. HATCHER 34
Abnormal Lignification in the Wood of Some Apple Trees. A. BERYL BEAKBANE and ELEANOR C. THOMPSON 36
Outdoor Tomato Trials, 1944. HILARY M. HUGHES 38
Weather Conditions during 1944. H. M. TYDEMAN and A. P. PRESTON 43

PAGE

BIOCHEMISTRY

Mineral Deficiencies in Agricultural and Horticultural Crops. W. A. ROACH 43
Progress in the Diagnosis and Cure of Mineral Deficiencies in Cherries. S. G. THOMPSON and W. O. ROBERTS.. 60
Combined Mineral Deficiencies in Fruit Trees. W. O. ROBERTS 64
Leaf Painting as a Method of Diagnosis of Mineral Deficiency. W. O. ROBERTS .. 67
Comparison of Diagnosis of Manganese Deficiency in Mangolds with Effects of Curative Spraying. W. A. ROACH and T. N. HOBLYN 67
Comparative Susceptibilities of Certain Horticultural and Agricultural Plants to Trace Element Deficiencies. R. J. GARNER and W. A. ROACH 70

PLANT PATHOLOGY

An Experiment on the Control of Crown Gall on Vegetatively raised Apple Rootstocks. H. WORMALD and R. J. GARNER 73
A Black Apple Rot caused by *Monilia cinerea*. H. WORMALD 75
Strawberry Leaf Blotch Fungus. H. WORMALD 76

ENTOMOLOGY

Notes on Some Interesting Insects observed in 1944. A. M. MASSEE 77
Observations on the Life Cycle of the Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.). R. M. GREENSLADE 83

HOPS

Cultural Trials with Hops. IV. The Effect of Distance of Planting and Hard and Light Pulling on Brewer's Favourite. F. H. BEARD 92

Section IV

BULLETINS FOR FRUITGROWERS

A Survey of Planting Problems. R. G. HATTON 96
A Guide to the Use of Fruit Tree Rootstocks. R. J. GARNER 98
Planning a Cherry Orchard. N. H. GRUBB 104
Accelerating Rootstock Research. A. BERYL BEAKBANE and ELEANOR C. THOMPSON .. 106
Recognition of "Rubbery" Condition in Lord Lambourne and Some Other Apple Varieties. A. BERYL BEAKBANE and ELEANOR C. THOMPSON 108
The Planting and Maintenance of Raspberry Cane Nurseries. N. H. GRUBB and R. V. HARRIS 109
Strawberry Runner Supplies and Certificates. W. S. ROGERS 113
The Bradbourne Walled Gardens. T. N. HOBLYN 115
Sprays to Prevent Pre-harvest Drop of Fruit. M. C. VYVYAN 118
The Cure of Deficiencies of Iron or Manganese. S. G. THOMPSON 119
The Control of Brown Rot of Apples in Commerical Orchards. H. WORMALD and M. H. MOORE 124
The Hop Red Spider (*Tetranychus telarius* L.). A. M. MASSEE 126
Codling Moth (*Cydia pomonella* L.). A. M. MASSEE 127
"Mercurated Lead Arsenate"—What is it? What does it do? H. SHAW and M. H. MOORE 128
Three Important Hop Diseases. W. G. KEYWORTH 130

GOVERNING MEMBERS OF THE SOCIETY

Appointed by the Ministry of Agriculture:

Sir Frederick W. Keeble, Kt., C.B.E., D.Sc., F.R.S., Celton House, Fowey, Cornwall.

Appointed by the Kent County Council:

Sir Edward Hardy, J.P., Boughton Court, Ashford, Kent.
T. D. Harris, Esq., O.B.E., Tudeley Hall, Tonbridge, Kent.
Major F. D. Thomas, Loose Court, Loose, near Maidstone, Kent.

Appointed by the Surrey County Council:

S. S. Boorman, Esq., "Birchley", West Clandon, Surrey.

Appointed by the East Sussex County Council:

E. S. Attrell, Esq., Warren Fruit Farm, North Common, Chailey, Sussex.

Appointed by the West Sussex County Council:

Gen. Sir Ivor Maxse, K.C.B., C.V.O., D.S.O., F.R.G.S., Little Bognor, Fittleworth, Sussex.

Appointed by the Council of the Senate of the University of Cambridge:

Professor F. T. Brooks, M.A., F.R.S., Botany School, Cambridge.

Appointed by the Senate of the University of London:

Professor Wm. Brown, D.Sc., F.R.S., Imperial College of Science and Technology, South Kensington, London, S.W.7.

Appointed by the University of Bristol:

Professor T. Wallace, M.C., D.Sc., A.I.C., The Research Station, Long Ashton, near Bristol.

Appointed by the Governing Body of the Imperial College of Science and Technology:

Professor V. H. Blackman, Sc.D., F.R.S., Imperial College of Science and Technology, South Kensington, London, S.W.7.

Appointed by the Council of the Royal Society:

Dr. E. J. Salisbury, C.B.E., D.Sc., F.R.S., 47 Kew Green, Kew, Surrey.

Appointed by the Governors of the South-Eastern Agricultural College, Wye:

A. Amos, Esq., M.A., Spring Grove Farm, Wye, Kent.
V. R. S. Vickers, Esq., South-Eastern Agricultural College, Wye, Kent.

Appointed by the Research and Advisory Committee of the South-Eastern Agricultural College, Wye:

S. G. Jary, Esq., B.A., Dip.Agric.(Cantab.), South-Eastern Agricultural College, Wye, Kent.

Appointed by the Governors of John Innes Horticultural Institution:

M. B. Crane, Esq., John Innes Horticultural Institution, Moreyn Road, Merton Park, London, S.W.19.

Appointed by the Council of the Royal Horticultural Society:

F. A. Secrett, Esq., F.L.S., V.M.H., Bell Farm, Felcott Road, Walton-on-Thames, Surrey.

Appointed by the Council of the Institute of Brewing:

Walter Scott, Esq., J.P., Messrs. Ansell's Brewery, Ltd., Aston, Birmingham, 6.

Appointed by the Research Fund Committee of the Institute of Brewing:

G. T. Cook, Esq., Queen's Avenue, Maidstone, Kent.

Appointed by the National Farmers' Union (Central Council, London):

J. S. CHIVERS, Esq., Messrs. Chivers & Sons, Ltd., Histon, Cambridge.
J. E. SANDALL, Esq., Beechwood, Clarkson Avenue, Wisbech, Cambs.

Appointed by the National Farmers' Union (Kent Branch):

ALFRED DAY, Esq., O.B.E., J.P., Great Tong Farm, Headcorn, Kent.
S. R. DIXON, Esq., Cambridge, Teynham, Sittingbourne, Kent.
W. T. EDMONDS, Esq., Allington Farm, Maidstone, Kent.
E. BRUCE GIBSON, Esq., Lumbersland, Birchwood, Wilmington, Dartford, Kent.
Sir AMBERSON B. MARTEN, Kt., M.A., LL.D., Gedges, Matfield, near Tonbridge, Kent.
A. T. MILLER, Esq., Wested Farm, Swanley, Kent.
D. J. MOOR, Esq., Nichol Farm, Teynham, Sittingbourne, Kent.
J. W. S. MOUNT, Esq., Little Barton, Canterbury, Kent.
T. NEAME, Esq., The Offices, Macknade, Faversham, Kent.
J. A. RAYNHAM, Esq., Dairy Farm, Marden, Kent.
J. M. ROBERTSON, Esq., Beluncle, Hoo, Rochester, Kent.
J. F. TOWNER, Esq., Salts Farm, Loose, near Maidstone, Kent.

Appointed by the Council of the Horticultural Trades' Association:

L. J. COOK, Esq., 7 Drapers Road, Enfield, Middlesex.

Appointed by the Associate Members of East Malling Research Station:

STUART MACDONALD, Esq., Little Baddow Hall, near Chelmsford, Essex.
Captain R. WELLINGTON, M.C., Worth, Hele, Bradninch, S.O., Devon.

Appointed by East Malling Research Station:

R. G. HATTON, Esq., C.B.E., M.A.(Oxon.), D.Sc.(Lond.), V.M.H., F.R.S.

Appointed by the Staff Council of East Malling Research Station:

W. S. ROGERS, Esq., M.A.(Cantab.), Ph.D.(Lond.), Dip.Hort.(Cantab.), A.Inst.P.

MEMBERS OF THE EXECUTIVE COMMITTEE

(Governing Members elected at the General Meeting, September, 1942)

ARTHUR AMOS, Esq., M.A.
Professor V. H. BLACKMAN, Sc.D., F.R.S. (Vice-Chairman).
Professor F. T. BROOKS, M.A., F.R.S.
Professor WM. BROWN, D.Sc., F.R.S.
J. S. CHIVERS, Esq.
G. T. COOK, Esq.
L. J. COOK, Esq.
M. B. CRANE, Esq.
ALFRED DAY, Esq., O.B.E., J.P.
S. R. DIXON, Esq.
W. T. EDMONDS, Esq.
E. BRUCE GIBSON, Esq.
Sir EDWARD HARDY, J.P.
Gen. Sir IVOR MAXSE, K.C.B., C.V.O., D.S.O., F.R.G.S.
T. NEAME, Esq. (Chairman).
J. M. ROBERTSON, Esq.
Dr. E. J. SALISBURY, C.B.E., D.Sc., F.R.S.
J. E. SANDALL, Esq.
Capt. R. WELLINGTON, M.C.

Co-opted Members:

H. V. TAYLOR, Esq., O.B.E., D.Sc.(Lond.), A.R.C.S., Horticultural Commissioner, Ministry of Agriculture.
W. ROGERS, Esq., Court Lodge, Horton Kirby, Kent.
Lt.-Col. Sir ALBERT STERN, K.B.E., C.M.G., Barham Court, Maidstone, Kent.

The Director:

R. G. HATTON, Esq., C.B.E., M.A.(Oxon), D.Sc.(Lond.), V.M.H., F.R.S.

The Representative of Staff Council:

W. S. ROGERS, Esq., M.A.(Cantab.), Ph.D.(Lond.), Dip.Hort.(Cantab.), A.Inst.P.

STAFF (June, 1945)

Director : RONALD G. HATTON,* C.B.E., M.A. (Oxon.), D.Sc.(Lond.), V.M.H., F.R.S.

Assistant to Director : T. N. HOBLYN,* Hort. Dip. (Wye).

Pomology : R. G. HATTON.*
W. S. ROGERS, M.A.(Cantab.), Ph.D.(Lond.), Dip. Hort.(Cantab.), A.Inst.P.
N. H. GRUBB, M.S.A.(Cornell).
J. AMOS, N.D.H. (*Deceased, March,* 1945).
Miss A. B. BEAKBANE, Ph.D.(Lond.), N.D.H.
R. J. GARNER, N.D.H., Dip. Hort. Sci. (Reading).
TH. RAPTOPOULOS, Ph.D.(Lond.). *Special Assistant.*
J. FLOOR, I.i.(Wageningen). (*On leave from Royal Netherlands Forces until September,* 1944.)
A. P. PRESTON, N.D.H. (*Appointed October,* 1944.)
Miss E. C. THOMPSON.
Miss E. M. GLENN, B.Sc.(Lond.).
Miss H. M. HUGHES, B.Sc.(Lond.), Dip. Hort.(Swanley).
Miss J. M. BUTTFIELD, N.D.H., Dip. Hort.(Swanley). (*Special Assistant, Nuclear Stocks Scheme.*)
Miss B. G. MOSSE, B.Sc.(Lond.), Dip. Hort.(Swanley). (*Appointed May,* 1945.)

Lab. and Field Assistants :
C. H. W. SLATER. (*On Active Service.*)
Miss E. C. M. ASHDOWN.
Miss F. M. HODGES.
G. WELLER. (*Workshop and Recorder.*)
Miss D. OLIVER. (*On Active Service, December,* 1944.)
Miss O. ROBINSON.
MRS. M. E. J. BINGHAM.
Miss D. E. A. YATES.
R. A. ADAMS. (*On Active Service, March,* 1945.)
C. F. MILLS. (*Appointed April,* 1945.)

Plant Breeding : H. M. TYDEMAN.

Marketing Investigations : A. C. PAINTER. (*On Active Service.*)

Walnuts : A. W. WITT, N.D.H. *Consultant.*

Hops : F. H. BEARD, Hort. Dip.(Wye).
Miss D. J. WILSON, B.Sc.(Reading). *Field Assistant, Hop Propagation.* (*Appointed April,* 1945.)

Statistics : T. N. HOBLYN.*
S. C. PEARCE, B.Sc.(Lond.).
Miss E. M. GLENN, B.Sc.(Lond.), (*Part-time—Records.*)
Miss A. SEARLE. *Computor.* (*Resigned April,* 1945.)
Miss J. M. THOM. *Computor.* (*Appointed March,* 1945.)

Plant Physiology : M. C. VYVYAN,* M.A.(Cantab.), D.Sc.(Lond.).

Lab. Assistants : G. F. TROWEL. (*On Active Service.*)
G. C. CHEESEMAN. (*Resigned September,* 1944.)
W. A. GIBBONS. (*Resigned September,* 1944.)

Biochemistry : W. A. ROACH,* D.Sc.(Lond.), A.R.C.S., D.I.C., A.I.C.
MRS. W. O. ROBERTS, B.Sc.(Wales). (*Seconded for War Service from Education Committee of City of Liverpool.*)
J. P. R. RICHES, M.A.(Cantab.).
S. G. THOMPSON, M.A.(Oxon.).
C. BARCLAY, M.A., Dip. Agric.(Cantab.). *Field Officer.*
Miss H. M. HOLMES, Dip. Hort.(Swanley). *Assistant Field Officer.*
MRS. A. M. HOUGH, B.Sc.(Liv.). (*Appointed May,* 1945.)

Special Assistant : Miss M. E. BUNYARD.

Lab. Assistants :
Miss E. M. PARKER, B.Sc.(Lond.).
Miss E. M. FORD.
Miss D. F. E. MARTIN. (*Re-engaged April,* 1945.)
Miss C. C. MACNAMARA.
Miss J. GANDON.
Miss D. E. T. HOOK. (*Resigned April,* 1945.)
Miss B. KIDWELL.
C. K. KING. (*On Active Service, May,* 1945.)
R. GREENFIELD. (*Resigned March,* 1945.)

Members of the Staff of the Imperial College of Science and Technology working in collaboration with the Biochemistry Section :
B. D. BOLAS,* D.Sc.(Lond.), D.I.C.
D. W. GOODALL, Ph.D.(Lond.), D.I.C.

Lab. Assistant : J. H. LAVENDER.

Plant Pathology : R. V. HARRIS,* D.Sc.(Lond.), A.R.C.S., D.I.C.
H. WORMALD, D.Sc.(Lond.), A.R.C.S., D.I.C.
M. H. MOORE, M.Sc., Dip. Hort. Sci. (Reading).
W. G. KEYWORTH, Ph.D.(Lond.), A.R.C.S., D.I.C.
I. W. PRENTICE, Ph.D.(Glasgow).
I. ISAAC, B.Sc.(Wales), Ph.D.(Cantab.), *Research Assistant, Hop Diseases.*
C. H. CADMAN, B.Sc.(Liv.), Ph.D.(Edin.). *Research Assistant, Raspberry Disease Investigations in Scotland.*
Miss M. P. ENGLISH, M.Sc.(Lond.). *Research Assistant attached to Plant Protective Chemistry.*
Miss M. BENNETT, B.Sc.(Lond.), Dip. Hort.(Swanley). *Field Officer. Also attached Entomology and Plant Protective Chemistry.*
Miss M. M. HITCHCOCK, B.Sc.(Reading). *Special Assistant, Hop Diseases.* (*Appointed July,* 1944.)

Lab. Assistants : R. D. SOUTER. (*On Active Service, November,* 1944.)
Miss B. I. FLEET.
Miss F. J. NEWING. *Virus Diseases.*

* Recognized Teacher of the University of London.

Entomology : A. M. MASSEE,* D.Sc.(Lond.), F.R.E.S.
G. H. L. DICKER, Ph.D.(Lond.), A.R.C.S.
M. D. AUSTIN, F.R.E.S. *Red Spider Investigations in Essex.* (*Appointed July,* 1944.)
E. T. BURTT, M.A., Ph.D.(Cantab.). *Research Assistant, Red Spider Investigations in Essex.* (*Appointed April,* 1945.)
P. H. TUFT, B.A.(Cantab.). *Special Assistant attached to Plant Protective Chemistry.* (*Resigned August,* 1944.)
Lab. Assistants : F. CRONK.
E. F. SOUTER.
J. LUCAS. (*Appointed April,* 1945).

Plant Protective Chemistry : H. SHAW, M.Sc.Tech., Ph.D.(Manc.).
J. K. EATON, B.Sc.(Wales), M.Sc.Tech.(Manc.).
Miss L. R. E. MARTIN, B.Sc.(Lond.), Hort. Dip.(Studley). *Assistant Biologist.* (*Appointed September,* 1944.)
Recorders and Lab. Assistants : R. G. GAMBRILL. *Recorder.* (*On Active Service.*)
D. A. MITHEN. (*On Active Service.*)
Miss A. J. COLLINGS.
J. T. GREAVES.
Miss M. PALMER. (*Appointed January,* 1945.)

Technical Section : H. B. S. MONTGOMERY, B.A.(Dublin), Ph.D.(Lond.), D.I.C.
N. B. BAGENAL, B.A.(Cantab.). (*Seconded to Ministry of Food. Resigned February,* 1945.)
B. F. G. LEVY, B.A.(Cantab.), Hort. Cert.(Reading). (*On Active Service.*)

Guide Demonstrator and Exhibitions Officer : Vacant.

Advisory Officers in Commercial Fruit Growing to the Kent Education Committee, stationed at East Malling Research Station : W. G. KENT, N.D.H., and C. R. THOMPSON (*Resigned*).

Experimental Nurseries : D. H. HAMMOND.

Experimental Greenhouses : A. TIDY.
Miss E. K. JOYCE.

Meteorological Records : H. C. CHAPELOW. (*Retired December,* 1944.)
A. P. PRESTON. (*Appointed October,* 1944.)

Photographer : Vacant.

Lab. Steward : R. G. GAMBRILL. (*On Active Service.*)

* Recognized Teacher of the University of London.

ADMINISTRATION.

Secretary : C. T. ROYLE.

Book-keeper : P. R. WOOD.

Farm Clerk : A. J. SPILLER.

Director's Personal Secretary : Miss L. E. ALEXANDER.

Clerical Staff : Miss J. M. COY, Miss G. O. ARDAGH, Miss H. D. GILMORE (*On Active Service*), Miss J. D. MARTIN (*On Active Service*), Miss M. G. ARNUP, Mrs. V. E. DUREY (*part-time*), Miss D. T. GARDNER (*Resigned October,* 1944), Miss B. K. WRIGHT (*Resigned July,* 1944), Miss L. M. GODDEN, Mrs. Y. GRAY (*part-time*) (*Appointed September,* 1944), Miss P. RAYFIELD (*Appointed December,* 1944), Miss M. M. ACOTT (*Appointed January,* 1945).

VISITORS.

The headquarters of the East Malling Research Station are at Bradbourne House, Larkfield, near Maidstone, and all visitors should enquire there for the Technical and Advisory Section.

Visitors coming by road should take the turning to East Malling, opposite " The Bull ", Larkfield, on the main London-Maidstone road. The entrance gate to Bradbourne is on the left approximately 300 yards down the road.

Bus Service : FROM MAIDSTONE by the Maidstone and District Motor Services Limited, every 20 minutes from Maidstone to Larkfield.

Passenger Station : EAST MALLING HALT (Southern Railway). *Goods Station :* Aylesford (Southern Railway).

Visits : Visits may be paid by appointment with the Technical Section on any weekday, Saturday afternoon under exceptional circumstances only.

Enquiries and Correspondence : All correspondence should be addressed to The East Malling Research Station, near Maidstone, Kent.

Telephone : Aylesford 7294 (2 lines). *Telegrams :* Research, East Malling.

THE IMPERIAL BUREAU OF HORTICULTURE AND PLANTATION CROPS

Accommodated at Bradbourne, the Administrative Headquarters of the East Malling Research Station.

STAFF.

Director : D. AKENHEAD,* M.A.(Oxon.), B.Sc.Agric.(Lond.).

Consultant Director : RONALD G. HATTON, C.B.E., M.A.(Oxon.), D.Sc.(Lond.), V.M.H., F.R.S.

Assistants : G. ST. CLAIR FEILDEN, B.A.(Oxon.).
V. H. GOLDSCHMIDT, Ph.D.

Clerical Staff : Miss M. B. ROGERS, Miss M. M. DURLING (*On Active Service*), Mrs. B. AKENHEAD, B.Sc.Hort.(Lond.).

Telephone : Aylesford 7294 (2 lines).

* As from October, 1945.

EDITORIAL

INEVITABLY the publication of our Annual Report has again been delayed, but we hope this will be to some extent compensated for by the inclusion of certain reports of particular interest at the present time, which might otherwise have had to be held over until next year.

We would like to remind our readers that the Report is divided into four sections. Section I gives a brief description of the work on the Experimental Farm during the year. Section II is intended to give other research workers and interested growers a general picture of the research work in progress at the Station, and includes summaries of reports that have appeared in scientific journals that may not be readily available to our Members. In Section III lines of work which have reached a stage when preliminary results can be given are reported on. It includes a brief description of the weather during the year.

Section IV contains fifteen bulletins prepared expressly for Fruitgrowers, these aim at informing the grower and the amateur how the latest results of research can be applied in practice. Some of these bulletins have already appeared in the Horticultural Press, and are here reprinted for the benefit of our Members, while others have been adapted from lectures given at Growers' Conferences and gatherings during the year.

This year the main responsibility for editing the Report has been undertaken by Mr. Hoblyn and Dr. Montgomery, but much assistance and advice has been given by Dr. Wormald, whose long experience has been invaluable in guiding the Report through the various stages prior to publication in an exceptionally difficult year. As usual Heads of Sections are responsible for the Sectional Reports.

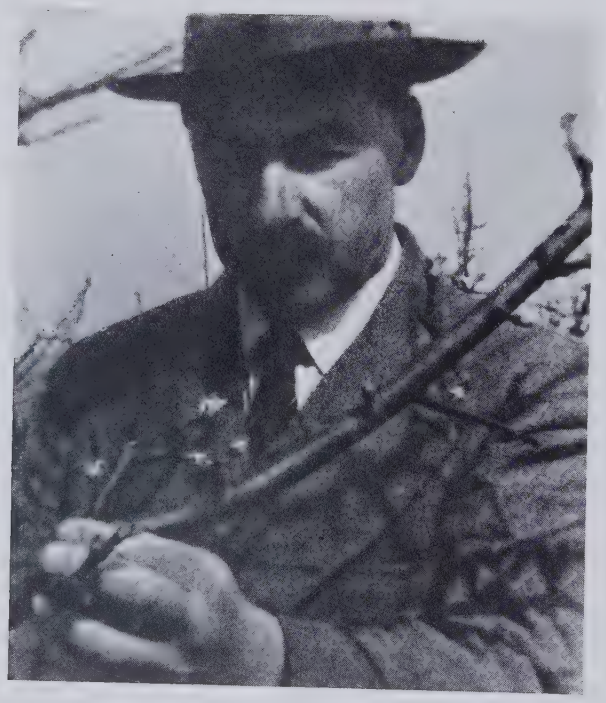
R.G.H.

October 1945.

JESSE AMOS

Chief Recorder and Farm Manager, East Malling Research Station

1913-1945



"JESSE" AT WORK

JESSE AMOS—AN APPRECIATION

Mr. J. Amos, " Jesse " as he was affectionately called by the wide circle of fruitgrowers and research workers who knew him as Chief Recorder and Farm Manager of East Malling Research Station, passed away at the age of 55 on Tuesday, 27th March, 1945. He was taken seriously ill only a week previously as he finished presiding at the Parish Council meeting, of which he had been elected Chairman a year ago.

Amos was born near Wye and attended the village school there, where he won prizes—given by the wife of the then Dr. A. D. Hall, Principal of Wye College—for proficiency in Botany. At about the age of 14 he went as assistant in the Botanical Laboratory at the College where Albert Howard (later Sir Albert) and, subsequently, S. T. Parkinson, were the lecturers, to whose interest he often stated that he owed much. He also came under the influence of Sir John Russell and probably of Sir Daniel Hall. Amos was of good agricultural stock, a born observer of nature, and he proved most receptive to the scientific atmosphere around him. Many are the College students who remember this ardent young demonstrator, always ready with the appropriate specimens at Botanical lectures and willing to help the keen in completing their collections or in cutting and mounting their sections. Amos was given charge of the Agricultural Botanical Collection in the garden at Fairdawn, where grasses were his speciality. However his work was also his hobby, and he roamed the Downs and the countryside in his spare time collecting plants and absorbing agricultural lore. Of the 21 species of orchids found in Kent, 19 were to be seen around Wye and Amos knew just when they flowered and where to find them.

It was at Wye too that he learned his photographic skill which, combined with his powers of observation and improvisation, produced so many of the fine photographic illustrations in East Malling Research Station's reports. When Wye College Fruit Experiment Station started at East Malling in 1912-3, the first director, Captain R. Wellington, wanted an assistant in his little field laboratory and someone to superintend the initial experimental plantings. There is little wonder that his choice fell upon this young botanist and born countryman. The bleak isolation of Great East Field, where Amos erected a wooden hut for tools and shelter and where for the first time he had to handle a horse and shim, was indeed a testing time for the young enthusiast, tenacious of purpose though he was. The outbreak of war in 1914 necessitated the turn over of the small farm mainly from experiments to food production, though the investigations had developed far enough to more than justify the maintenance of the trials already laid down. Only one worker was able to give his whole time to the activities of the Station between 1914-8 and that was Amos, who had to find out how in strange surroundings to carry on a scantily equipped place as best he might. His contacts with students at Wye had already given him an exceptional knowledge of how to handle his fellow men and this new responsibility undoubtedly developed his wonderful gift for improvisation and brought him face to face with the job of getting the best out of the land. He learned to become a good cultivator by having to do the jobs himself. He turned his botanical interests and gifts to an enthusiastic collaboration with the first and second Directors in the description and identification of rootstocks and small fruits, which were the foundations of the Station's success. It was at once a delight, a stimulus and an education both to make observations and carry out manipulations with him in the field, or to verify details at the laboratory bench. Amos was a great colleague and although he was not himself a gifted writer—possibly partly because he was never a great reader—his name has always been closely associated with this initial work and his large share in it widely acknowledged and appreciated. Actually some 20 published reports on various aspects of fruit research, ranging from the classification of red currants to the pruning of pears, bear his name. In 1924 he took the National Diploma in Horticulture in his stride.

Jesse was known by and appealed to a very wide circle of friends—scientists, immediate colleagues and the many different types of fruitgrower who came to the Station to look around or seek advice.

Despite his crowded life, Sir John Russell never forgot the lad at Wye and on seeing the announcement of his death wrote : " I had known him since he was a boy in a class I used to take at the Wye Village school when I worked out ' lessons on soil '. He was always a very keen and good solid worker. He did very well later in the Botanical Lab. with Parkinson ".

Professor E. S. Salmon, who had also known him from his Wye days and as a collaborator in the testing and selection of his new varieties of hops, expressed the thoughts of so many when he said " I admired him as a laboratory boy at Wye College for his character and for his resourcefulness in obtaining unlimited supplies of plants for ' botany '. It has always been a joy to think of his leaving Wye for your Station where he was able to enjoy a fuller life and to develop the great natural abilities he had—he had the ' instinct ' of being able to recognize ' habit ' in plants. I shall always remember his way of drawing himself up, squaring his shoulders, when he stated what he felt was an

important fact. Also, too, I shall remember a peculiar gentleness in his voice when he greeted you or said goodbye ".

Captain R. Wellington, who brought him to East Malling when he started the Experimental Station, writes : " I personally owed a great deal to him, first, whilst still a student at Wye. I think I learned more Botany from him than I ever did from lectures—but also at East Malling. The fruit-growing community don't know how much they owe to him and never will. He was just like a large granite rock, absolutely stable and always set in place. Nothing much seemed to perturb him ".

One of his colleagues on the staff has expressed another aspect of Amos' character so well. " It is hard to write as one would like as so many memories come welling up,—his imperturbability, his little mannerisms, that characteristic pause before he answered a question, his innate kindliness and readiness to help. This last trait of his especially impressed itself on those, who like myself, were often in need of guidance and advice. Once convinced that you needed his advice it did not matter whether it was some important grower, some harassed recorder or some humbler individual, for all he would go to infinite pains and give of his best, though it was characteristic of him that it would frequently be given at his own time and in his own way."

Visitors to the Station " always used to look forward to a chat with Jesse "—" that lovable landmark "—" that cheery greeting " which made everyone " regard him as a close personal friend ". From overseas and abroad come similar testimonies to the writer's " oldest associate and one of his best friends—the words ' Amos and I ' have been very characteristic of your common work in so many of your speeches and writings and we understand what you have lost "—" a great colleague, one of the links with the past, with the beginnings of your great venture ", " during those critical years following the establishment of the Station when ", as Professor Barker writes, " the work of the few available influenced so much of its future development ".

As the research farm gradually grew from 23 to 60, and from 160 to 360 acres, so Amos had more and more to surrender the details of observational and photographic work to others and to develop into that unique link between the exacting requirements of the horticultural scientist and the demands of large scale farming. He never seemed to hurry or to be outwardly perturbed at the rush of small requisitions for help on the experimental plots. His judgment in selecting the most urgent requirements and in finding a way out of difficulties gave everyone confidence. He rarely if ever lost his temper, he handled the many different types of people he had to serve with tact and humour, and, against heavy odds, he kept the research station looking like a fruit farm. In the early years of the Institute's development, Amos had been closely associated with Professor Salmon in the testing of the new Wye varieties of hops. He had also been interested in the variety trials of corn and potatoes and so when the second world war called for a maximum output of primary food crops, he threw himself wholeheartedly into the 160 acres of arable cropping on Park Farm, the condition of which visibly improved under his supervision.

It is perhaps true to say that Amos was the ideal recorder rather than the born experimenter. In later years his interest in distinguishing varieties was maintained by the naming of fruits, at which he was becoming proficient. His intimacy with County tradition made him suspicious of innovations, though once he was persuaded that they were for the benefit of the Station he loyally did his best to make them work. The research station was Amos' pride and it is difficult to think of the one without the other.

From the first Amos threw himself into the activities of his adopted village. He was a parish councillor for over 20 years and then Vice-Chairman and Chairman. He was a member of the Committee of Management of the village Social and Sports Club and was always in evidence arranging for and participating in village Charitable Fêtes. He used to enjoy a game of cricket both in the village and Research Station teams in his younger days, and he was an indispensable member of the Station's "Oasterers" at Christmas gatherings. A man of simple piety, he was connected throughout his life with the activities of the Parish Church, being for many years a member of the choir, a parochial church councillor and a sidesman. During the last war he was a Local Defence Volunteer and during the present war he worked throughout with the A.R.P. as a warden and in addition was chief Billeting Officer. He was keenly interested in the betterment of his fellow men and for a time was Secretary of the local branch of the Agricultural Workers' Union; after attending a Summer School at Balliol College, Oxford, he joined in the activities of the Workers' Educational Association. He was super-sensitive to all forms of suffering and cruelty so much so that, although he took a delight in every form of wild life, he could never bring himself to carry a gun.

He leaves a widow and one daughter.

Horticultural scientists, fruitgrowers and the locality, all learned to regard this forthright countryman as a staunch friend and a wise counsellor who was always ready to give the benefit of his wide experience. The words " Where's Mr. Amos ? " and " Let's ask Jess " were on everybody's lips, but he always kept a placid exterior whilst seeking his prodigious memory for the appropriate answer.

R.G.H.

Section I

THE EXPERIMENTAL FARM

Edited by T. N. HOBLYN, with contributions from C. BATES, F. H. BEARD, E. BIDWELL, D. H. HAMMOND and H. M. HUGHES

The year 1944 was one whose passing will not be regretted by many farmers, particularly fruitgrowers. The prolonged winter and spring drought (the rainfall from November, 1943, to June, 1944, at the Station was just half the normal), followed by an exceptionally wet autumn, made all farming operations difficult. For many fruitgrowers, however, this was not the worst of the season, for on the 8th and 9th May, towards the end of what had seemed a blossoming season of much promise, the country was once more subjected to severe frosts which did great damage to all fruit crops. At East Malling the season was the most disastrous since 1935, nearly all top fruits and much of the small fruit being wiped out.

Experimental Orchards.—Top Fruits.—*Apples.*—The total crop from some 50 acres of apples was 1,500 bushels (40 lb. to a bushel) the smallest since 1935. The more frost susceptible varieties, such as Bramley's Seedling, gave negligible crops. Worcester Pearmain had cropped regularly for eight seasons achieving its maximum crop for the whole farm in 1943. In 1944, though by no means an " off " year, blossoming was only fair. This and its previous cropping record may have something to do with its comparative lack of resistance to frost damage in 1944, only a few trees in favourably situated parts of the farm producing small crops. Of all the main varieties only Lane's Prince Albert gave an appreciable crop of about 600 bushels ; the long blossoming period of this variety may have been responsible for this result. In the plantation top-worked to late blossoming varieties in 1940 several of those which carried sufficient blossom escaped serious damage and bore fair crops. Of these Edward VII and Royal Jubilee may be mentioned. It is also worthy of note that Heusgen's Golden Reinette and Orleans Reinette, both of which were in full bloom when the frost occurred, also cropped comparatively well.

Pears.—Most varieties were in blossom in the third week in April, when conditions for pollination were good, and had set very well. This may have been the reason why several varieties bore considerable crops of fruit which, though seedless, were able to mature. Conference, which again averaged over two bushels to a tree (48 lb. to a bushel), is well known for this capacity to mature seedless fruit; but in this season Dr. Jules Guyot, Fertility, Emile d'Heyst, Durondeau and Beurré Clairgeau also bore up to one and a half bushels a tree. The total crop of pears from some 7 acres was 1,250 bushels.

Plums and Cherries.—Most of the Czar plums remaining on the Station are either in windbreaks or nearing the end of their time as filler trees in a cherry orchard and are not in a very vigorous condition. This may account for the failure of this variety this year to live up to its reputation at East Malling for frost resistance. Only a few younger trees of Czar and Victoria plums in a sheltered situation on the farm bore any appreciable crop. The total crop for the whole farm was only 400 half sieves (28 lb. to a half sieve). The cherry crop failed entirely.

Small Fruits.—As noted in last year's Report the Station has now no appreciable area of soft fruit in cropping, except small areas under various experiments. It is therefore hardly possible to give any general picture of their cropping. It may be noted however that, despite the frost and early drought, the rain came in time to benefit raspberries and loganberries and fair crops were obtained of both.

A new black currant plantation of about 6 acres was planted in the spring. Part of the plantation is already devoted to variety trials and a trial of straw applications as a substitute for dung in preparing the ground before planting. T.N.H.

Experimental Nurseries.—There were some 38 acres occupied by nurseries during 1944, including 17 acres of stool-beds and 4 acres of strawberries. Various experimental tree nurseries occupied 1 acres, while black currant, raspberry and loganberry propagation beds, Myrobolan B and Marianna cuttings and bedded stocks accounted for 13 acres.

The crop of stocks from the new 10-acre stool-bed did not give the number of first grade stocks which had been expected. Rooting on the whole was good, but the stocks were not so vigorous ; this was probably due to the dry spring and quite a number were cut back to ground level by the May frosts.

The old stool-bed in Newgates Field, planted in 1928, is becoming too old for economical earthing,

and will be gradually grubbed now that the new stool-bed in Ditton Fields is coming into greater production.

Some 1,146,500 rootstocks of all grades were harvested, and of these some 781,500 grade 1 and 2 stocks were distributed amongst the Members of the H.T.A. and to Associate Members. 365,000 very poorly rooted stocks were bedded back at the Research Station for a further year. The demand for rootstocks was more than double the number available, orders being received for very nearly two million and though we tried to allot those available as fairly as possible, it is feared that many who ordered the more popular varieties were disappointed.

Some 40,000 raspberry canes, mainly of the new seedling varieties bred at East Malling, were distributed and the planting of the propagation beds laid down in 1943 was completed.

The ½-acre of clonal loganberries produced some 5,400 rooted tips.

The 2 acres of Royal Sovereign produced some 80,000 first grade plants. These were lifted under very bad weather conditions. The ground was so wet that it was not possible to shake the soil from the roots of the plants; luckily a stream was close at hand and by placing the plants in wire baskets and allowing them to remain in the running water for ten minutes or so most of the soil was removed. It was in this way possible to keep the weights of consignments down to the normal when packed. Some 36,000 Huxleys were also produced and dispatched.

The 15 daughter nurseries produced some 1¼ million Royal Sovereign and 2½ million Huxley plants.

The Myrobolan B cuttings did exceptionally well. 75% good plants were produced; normally about 50% is the average.

24,000 black currants were distributed as 2-year-olds. These were a very fine sample, rather too large for packing, as so many extra bundles had to be made to meet the Railway Companies' regulations as to weight allowed by passenger train. Some 16,000 1-year bushes were retained in the nurseries for a further year. D.H.H.

Outdoor Tomatoes.—After the excellent weather conditions for this crop in 1943, the season of 1944 was disappointing. Exceptionally dry conditions prevailed before and after planting, which were not entirely remedied by irrigation. Dull and wet weather in August and September caused slow ripening and much splitting of the fruit. The high proportion of "blotchy" tomatoes was possibly due to low available potash aggravated by this dull weather. Blight caused some wastage amongst fruit brought in to ripen off. A total of 6¼ tons of ripe fruit was sold off 1½ acres, of which only 2½ tons were of top quality. H.M.H.

Arable Crops.—In 1944 there were some 160 acres under arable crops, including 30 acres of seeds hay and 5 acres of kale and cabbage for cattle feed. During the season 1943-4 a yard of 55 head of cattle was maintained and produced some 800 tons of manure.

Potatoes.—Forty acres of Majestic were grown. At the time of writing owing to restrictions on sale, the total crops cannot be given. Part of the potato acreage was devoted to a large scale demonstration of the effect of applications of straw on the cropping of potatoes and succeeding crops. Four strips, each of rather over an acre received applications, partly of new straw at 3 tons per acre and partly of wet, partly-rotted straw at 4 tons per acre, in January. With the straw, 2½ cwt. per acre of sulphate of ammonia was given. Four similar strips received no straw, and one strip through the centre of the field had short farmyard manure at the rate of 12 tons per acre. The whole area had 8 cwt. of flue dust per acre and was ploughed early in February. At the time of planting the wartime dressing of 3 cwt. sulphate of ammonia, 2 cwt. superphosphate and 1 cwt. muriate of potash was applied up the drills throughout.

At the time of lifting, sample plots from all strips were dug separately and the crops recorded. Smaller samples were graded for size and the occurrence of Scab.

The crop from the whole of this area was good, with over 90% ware. Although there was no difference in the size of the potatoes, the straw plots yielded at the rate of about 27 cwt. per acre more than those which had no straw.

Straw plots—14 tons 14 cwt. per acre.

No straw—13 tons 7 cwt. per acre.

The strip that received dung gave a crop practically the same as the straw plot adjacent to it. A considerable proportion of the ware potatoes had some Scab, especially in certain parts of the field where the soil is rather different from the main part. The plots receiving straw had rather more Scabbed potatoes than those that did not. The increase in potato crop itself would hardly pay for the considerable labour in carting and distributing the straw, but it must be remembered that the main object of these arable crops, apart from their immediate contribution to the national larder, is to build up the fertility of the land, and the residual effect may be of more value than the immediate one on the potatoes. Fifteen months after the application, portions of the straw are still visible, and the effect on the yield of the succeeding crop of wheat will be recorded if possible.

Cereals.—Twenty-eight acres of Als wheat yielded 6½ quarters to the acre. Thirty-five acres Plumage Archer barley averaged rather over 4 quarters to the acre. Thirteen acres of SS172 also gave just over 4 quarters to the acre.

Twenty-seven acres of barley were undersown with seeds in the spring.

Seeds Hay.—Seeds hay, like other crops, suffered from the winter and spring drought and the cut was very poor.

Hops.—The acreage remains unchanged at 9¾ acres—8¾ acres of new varieties and Fuggles in am and Church Fields, and 1 acre of Goldings at Bradbourne. No extensive grubbing or replant- was done, but a few rows of seedling varieties were grubbed to make way for newer selections n Wye. Neither insect pests nor fungus diseases were unduly troublesome and the entire crop picked in excellent condition. Some very attractive samples of the clonal Goldings and of the ied Wye varieties were produced. All yields were considerably down on previous years owing rought in spring and early summer. However, the rains came in time to benefit the late New ican seedlings which, in contrast to recent years, once again bore the very large cones for which are noted.

Our total growth amounted to 6¼ tons, which was about ½ ton greater than 1943 (because a greater portion of plantings had reached maturity).

A table of prices received in 1944 is given below. This year for only one of the New Varieties, ion, is a comparison possible between the ordinary valuation and that on a P.V. (10α) basis. It f interest to note that during the last three years the average prices for Bullion have been nary valuation £20 12s., valuation on P.V. basis £27 10s.

Raising sets for distribution to growers and for use by the Pathology Section in connection with r hop diseases investigations, is now a considerable item in the year's work. Some 6,000 sets of new varieties were raised and distributed among 12 growers. For some varieties, notably Bullion College Cluster, the demand greatly exceeded the supply. Some 5,000 sets were raised for the of the Pathology Section mainly for the Verticillium Wilt investigations. Small quantities of al Fuggle and Goldings were distributed to a few growers for the establishment of isolated pagation gardens.

Variety.	Ordinary Valuation.	Valuation on P.V. (10α) basis.
	£ s.	£ s.
Brewer's Gold (C9a)	22 10	—
Bullion Hop (Q43)	22 10	30 6
Brewer's Favourite (OP21)	21 0	—
Quality Hop (0063)	20 10	—
Fillpocket (Z62)	21 5	—
College Cluster (N15 bis)	20 0	—
Brewer's Stand-by (HH44)	21 15	—
Malling Midseason (BB28)	21 5	—
Early Promise (X35)	19 0	—
OH44	19 0	—
OI47	19 0	—
R3/100	22 10	—
Mixed Growths (Manitoba)	20 5	—
,, ,, (New Mexican)	18 15	—
,, ,, (others)	19 15	—
Fuggle	18 0	18 6
Bramling	21 0	14 18
Canterbury Golding	19 0	18 4
Early Bird	21 0	27 3
Eastwell Golding	19 0	18 2
Mathon	21 0	22 2
Petham Golding	21 0	18 8
Rodmersham Golding	19 0	18 2
Cobb's	—	18 12

Routine Spraying Programme.—In spite of the loss of most of the fruit crop due to the spring s, the 1942 spray calendar was followed with only slight modifications, as past experience had hasized the importance of keeping the trees free from pests and diseases.

Although tar oil spraying was not begun until 5th January, open weather permitted the spraying ost of the apples and all the pears and cherries during the next fortnight. The apples that received

tar oil were sprayed during the last week in March with petroleum oil emulsion (6% actual oil), wit the exception of certain plots under various manurial treatments for which the strength of oil wa halved to reduce the risk of damage. The remainder of the apples and all the plums received single D.N.C. petroleum wash during the second week of March.

The normal pre-blossom lime-sulphur and arsenate sprays were used on all apples, save thos on the manurial trials mentioned above, for which the strength was reduced, but since pink bud stag followed closely on green-cluster (green bud), the strength of the lime-sulphur at pink bud was reduce to 1½% and lead arsenate generally omitted. Lead arsenate was used in early June, wherever ther was any fruit, against codling.

As the pear blossom developed very rapidly, there was time for only one pre-blossom lime-sulphu spray to which lead arsenate was added, and this was followed by two post-blossom sprays of Bordeau mixture. Lead arsenate was applied during the third week in June to protect the fruit from codlin attack.

All sweet cherries received the routine applications of Bordeaux mixture in April and Novembe against Bacterial Canker. The autumn spray was delayed rather later than recommended owin to unsuitable spraying weather.

Raspberries had 5% lime-sulphur at the beginning of April for cane-blight, followed by Bordeau mixture plus nicotine in the third week in May. One application of lonchocarpus and soap at th end of June gave sufficient control of raspberry beetle.

Loganberries were sprayed twice with lonchocarpus for beetle and good control was achieved Nicotine to control aphis was added to the combined cane spot and beetle spray in mid-June.

Downy Mildew on Hops was readily controlled by two sprays of Bordeaux mixture this season For aphis control, two sprays of nicotine and soap were applied at the end of June and the begin ning of July, and nicotine was added to the lime-sulphur spray against red spider in July, as we as to the other two routine sprays against mildew.

Section II

GENERAL REVIEW OF RESEARCH WORK

WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

By R. G. HATTON and W. S. ROGERS

A.—Tree Fruits.—Rootstocks.—The long-term rootstock trials of apples, pears, plums and cherries have been maintained. Trees on the most dwarfing apple rootstocks still show good leader growth and no signs of senility at the age of 27 years.

The trials of pears on quince rootstocks have provided material for a paper on the cropping of pears at East Malling from 1921-43 (See II, E211).

New Nursery and Field Trials.—The apple rootstock trials established on five different soil types in Kent are all reaching the full cropping stage and giving useful information on the relation between soil, climate and rootstock effect.

Two preliminary trials of new apple rootstocks, bred in one case for immunity to woolly aphis, and in the other for other desirable characteristics, planted out in 1942-3, have helped to provide data for the ultimate selection of rootstocks for the full-scale trial plantations. The trees on immune rootstocks have now been worked and will occupy some 5 acres on two distinct soil types on the Bradbourne land ; three varieties on 20 new rootstocks with suitable controls are included. These immune rootstocks are expected, from anatomical and nursery tests, to give vigour ranging from very dwarfing to very vigorous. The varieties are Jonathan, Cox's Orange Pippin, both of international interest, and Ellison's Orange, which shows some degree of inherent resistance to spring frost.

Apple trees for new cultural trials which will cover some 12 acres have also been worked. The rootstocks chosen are M. IX, for plantations of dwarf trees, and M. II and M. IV for larger bush trees at 18 feet square. The scion varieties will be Cox's Orange Pippin, Ellison's Orange, Fortune, Laxton's Superb and Sunset. (See also II.)

Rootstocks for cordons and intensive culture.—A paper has been written, and will be published early in 1945, on three trials of Cox's Orange Pippin and Worcester Pearmain apples grown as single oblique cordons, including different rootstocks, two different pruning methods, and two spacing distances. Two popular bulletins on cordon culture, based on the findings of this trial, have been published (E209, E212). These include recommendations for rootstocks, planting distances, training and pruning.

In a nursery trial reported on (E210), high worked Napoleon Bigarreau sweet cherries proved less susceptible to bacterial canker than low worked ones, and the Malling Mazzard selection F12/1 was more resistant than seedling Mazzard from any one of four sources.

Two preliminary trials of acid cherry rootstocks worked with Frogmore were established in the form of bush trees. One of these trials will serve for a preliminary test of pruning trees of this type. Further batches of selected acid and sweet cherry rootstocks were raised for further budding trials.

Classification and Identification.—The work of bringing up-to-date the detailed descriptions of the botanical characters of the various additional rootstocks found in commercial circulation or recently introduced thereto, and of making identification keys for them, has progressed ; certain difficulties, inherent in the close similarities of some of these varieties within single species, have hindered the completion of the identification keys.

Inarching.—A detailed examination of 21-year-old trees of Grenadier, originally on Malling Crab H and Northern Spy, inarched with M. XVI in 1934, was begun in collaboration with the Biochemistry Section (see IV). Leaves were taken for analysis, dyes were injected to study the regional effect of the inarches and preparations made for excavating the multiple root systems.

Histological Investigations.—The anatomical work on apple roots has been continued. Observations on plum and cherry roots have indicated that there is a correlation between the percentage of living tissue in the roots and the vigour of the scion variety in these fruits, similar to that already shown to exist for apples.

A study of the stem structure of fruit tree rootstocks has been started.

Studies of the structure and lignification of stems of the apple variety Lord Lambourne said to be suffering from " rubbery wood " trouble have been made.

Propagation.—A new layer bed of selected plum and cherry rootstocks was established on the Bradbourne land and made excellent growth in its first year despite the early summer drought. The collections of apple, pear, quince, plum and cherry rootstocks in commercial circulation were also re-established in convenient form for identification studies. This collection, numbering seventy-two kinds, will be stooled or layered each year in order to provide growth comparable to that commonly seen in commercial nurseries and, in addition, a few of each will be planted every year to provide bedded rootstocks for comparison. The full complement of woolly aphis immune apple rootstocks selected for propagation qualities, including the 20 preliminary selections for the large-scale trials mentioned above, was budded with Cox's Orange Pippin, Ellison's Orange and Jonathan to provide trees for further trial. Maiden trees of Cox's Orange Pippin and McIntosh Red on some of these selections, intended to show up any signs of incompatibility, made good growth during the year in spite of a severe late spring frost and manganese deficiency in the nursery ; and no sign of incompatibility has yet appeared. The maiden Williams' Bon Chrétien pears, budded in 1943 direct on a wide range of quinces, made excellent shoot growth, typical of such combinations, but some definite incompatibilities began to appear by the end of the season, as shown by clean breaks at the union.

Experiments with hardwood cuttings were especially designed to elucidate the influence on rooting of source of cutting material and of environmental conditions. The demand for information on the rapid production of particular clonal rootstocks was met by using such material in trials. Trials repeated included the taking of cuttings from a differentially manured hedge and from different positions along the shoot. Hedges of rootstock varieties were planted at East Malling and on the Bagshot Sand at Woking to provide cuttings grown under differing soil conditions.

Preliminary heat treatment of hardwood cuttings, combined with the use of a growth substance, were repeated in a modified form. The first trial revealed that rooting could be improved by these methods. (See also II and III.)

Graded cuttings of the two plum rootstocks Brompton and Myrobolan B planted in four soils, two in Surrey, one in Malling loam, and one in the drained Bradbourne lake, in the autumn of 1943, made poor growth where soils were dry, as in Surrey, but grew well in the moist lake soil. The good stand of the Brompton cuttings indicated that this rootstock can be fairly readily propagated by hardwood cuttings, at least in some seasons.

Spacing trials with hardwood cuttings of the plum rootstock Myrobolan B were repeated. The previous trial indicated that spacing has a considerable effect upon size and shape of rooted cuttings, but that such effects are related to soil conditions.

Small root cuttings of the vigorous apple rootstock Malling Crab C, collected from maiden trees and planted in the spring, gave an excellent stand of rootstocks, more than half of which were fit to line out for budding by the autumn.

Rootstocks were budded with selected scions to provide material for investigating the possible effect of the scion upon the regeneration of root-cuttings taken from the rootstock.

Layering technique investigations were confined to the treatment of plum layers with the growth substance, indolebutyric acid, in solution and in dust form, applied at intervals during the summer. Observations through the season and records of yield of rooted layers revealed no effect due to treatment.

In connection with the wilting of plum and cherry shoots in layer beds, four cherry rootstocks, two acid and two sweet, and five plum rootstocks root-dipped in Bordeaux mixture 10 – 10 – 100 and 20 – 20 – 100 grew normally. Such treatment would appear to be safe for these rootstocks. This trial was undertaken in collaboration with the Pathology Section. (See V.A.)

A technical communication was published, entitled " Propagation by cuttings and layers. Recent work and its application, with special reference to pome and stone fruits ". (Eg 29.)

Double-working.—Observations of single- and variously double-worked Williams' Bon Chrétien pear trees planted at East Malling and on a farm near Faversham have been maintained. At 5 years old, there are indications that intermediates of Beurré Hardy are likely to prove superior to intermediates of the varieties Beurré d'Amanlis, Fertility, or Hessle. It is interesting to note that most of the surviving single-worked Williams' on Quince A are making vigorous extension growth, but are liable to snap at the union under any sudden stress.

An article on the double-working of pear trees was published in the nursery trade press and a growers' bulletin appeared in the Annual Report for 1943 (Eg 28, E30).

Cover Cropping.—A trial of annual cover crops grown under mature apple trees for three successive years has been concluded, and the data have been summarized for a report. They show that even in such a short time the soil organic matter can be appreciably increased, with beneficial effects on the crop of the trees, and without checking tree growth.

A trial was made of time of turning-in a short-term ley, under mature trees. The sward, consisting of grasses and clovers, was turned-in late in the autumn and early in the spring, with and without added nitrogenous fertilizers intended to compensate for the nitrogen used by bacteria in rotting the sward. Surprisingly little difference in growth of the trees under these four treatments was found ; all had good foliage and grew well. Further developments will be watched with interest. It is probable that the unusually dry March, April and May affected this result, and also enhanced the checking effect of other cover crops grown in 1944. A lucerne cover crop, sown with the object of lessening the growth of some vigorous frameworked trees of Cox and Worcester, considerably checked their growth and increased their crop. Another trial of annual cover crops and short-term leys on young Cox and Worcester trees on M. IX has shown interesting results in its first season.

A repetition of a trial to find out the best time of sowing and the least harmful time for spraying over annual cover crops, with a view to minimizing spray damage, confirmed the findings of the previous year, namely that plants sown early enough to become well established are relatively little damaged either by winter weather or winter washes, especially if the winter washing is deferred till as late as possible. The data are being summarized for a report.

The trial of a grass sward compared with clean cultivation under standard sweet cherry trees, is now reaching the stage where effects on the trees can be seen.

Inorganic Fertilizers.—The long-term trials of inorganic fertilizers have been maintained. No appreciable leaf scorch has yet appeared in apple trees which have now had no potash for five years, but had received 4 cwt. per acre of sulphate of potash in each of the preceding 5 years. Further results have appeared in the trial of control of interveinal scorch by application of magnesium sulphate on the soil, and once more sulphate of ammonia has also reduced the symptoms.

Soil moisture.—Extensive investigations with soil moisture tensiometers in orchards and other plots under various cover crops have provided valuable data on the demands made on soil water by different cover crops. Large differences in time and amount of water depletion from different soil layers reflect the difference of root range and time of growth of the cover crops. These results are materially helping in the choice of cover crops for different conditions and in the interpretation of experimental results.

Pruning.—The light " renewal " pruning method, carried out in collaboration with the Kent County Horticultural Officers, on the rootstock trial plots on various soil types in the County and some plots at the Research Station continued to give interesting results.

A small trial of longitudinal slitting of the bark on branches of Worcester Pearmain trees in a weak state of growth, carried out to see whether it helped to stimulate new shoot production, gave negative results in the first season.

Frost Damage Investigations.—The trial of late-blossoming varieties, frameworked on older trees, gave particularly interesting results in 1944, for, in spite of the spring frost which destroyed most of the crop of Cox and Bramley, several of these varieties including Edward VII, Heusgen's Golden Reinette, Crawley Beauty and Royal Jubilee, and to a lesser extent Granny Smith and Orleans Reinette, gave quite a good crop. (See also under Breeding.)

Air temperatures were recorded during the blossom period of a cherry and plum orchard over grass and bare soil strips, 100 feet wide, at heights of 3 ft. and 5 ft. 6 ins. Very slightly lower minima and higher maxima were recorded over the grass, but the figures did not differ significantly from those over clean cultivation.

Biennial Bearing.—The spring frosts of 1941 and 1944 cut across the results of the pruning and bud-rubbing experiments, designed to investigate possible control measures for biennial bearing on Miller's Seedling, but one treatment showed signs of promise.

Provision has been made for further work on this subject by the inclusion of Laxton's Superb in the trees worked for planting in 1945-6.

Varieties and Classification.—The cordon collection of apple and pear varieties, numbering some 250 has been maintained. Preparations have been made for working the whole collection of cherry varieties, which has been gradually accumulated over some thirty years, on to one rootstock, Mazzard F12/1, in one season, so that a new orchard can be planted in which better comparisons can be made.

Four new cherries, Merton Heart (404), Bigarreau Merton (193), Merton 185 and Merton 490, raised by the John Innes Horticultural Institution and selected by the R.H.S. National Fruit Trials Sub-Committee for Cherries, were at the Committee's request, budded to the Mazzard rootstock Malling F12/1. The four established commercial varieties Early Rivers, Roundel, Waterloo and Bigarreau Napoleon were also budded on Malling F12/1 to serve as control trees and pollinators. The resulting trees are intended for planting at five centres.

A collection of 17 varieties of apricot has been planted for observation, at Bradbourne.

Breeding.—Observations have been continued on the two to three thousand apple and pear seedlings already under test with a view to selecting individuals of commercial promise. Special

attention has been paid both to the season of flowering of the apple seedlings, with the object of finding seedlings sufficiently late flowering to escape spring frosts, and also to any inherent resistance combined with other valuable characteristics. Material is being prepared for an extensive programme of crosses between frost resistant and late blooming apples from which it is hoped that a range of commercial apples capable of withstanding frost conditions will be obtained. A number of promising new varieties have been selected and are being further studied. Several of them are now under test in growers' plantations scattered throughout the Southern Counties. A paper outlining the results of the past fifteen years apple breeding work and describing the characteristics of the families raised has been published. (E207.)

B.—Small Fruits.—Classification, Nomenclature and Varieties.—*Raspberries.*—The crop of 1944, though somewhat reduced by the frosts of May, was in several ways interesting. Seedling " L " (34/42), with nearly three tons per acre, again gave more weight of fruit than any other variety in the main trial, though it was less ahead than in 1942 and 1943. On the average of three years it has yielded nearly 40 per cent. more weight of fruit than the next best.

Somewhat surprisingly, the second in weight of crop was Seedling " H " (32/180), to which more attention must now be paid. The remaining varieties in the trial came in the following order :— " J " (33/54) ; Norfolk Giant ; " K " (33/115) ; " G " (33/166) ; " F " (32/94) ; " E " (33/132) ; and Baumforth B. The only reason why " E " was so low was a somewhat severe attack of Cane Blight, to which it now seems rather susceptible ; the crops of " J," " G " and " K " were also slightly reduced by this disease.

The small trial of Seedlings " M " (32/138) and " N " (32/163), with " J " for comparison, planted a year later than the main trial, cropped somewhat more heavily, probably owing to closer planting ; all three varieties yielded more than 3 tons per acre, " M " and " J " not far short of 3½ tons. For a frosty year this may be considered good.

Records of fruit size and quality fully confirmed those of previous years. " E " was again the largest (*not* owing to the reduction of crop by Cane Blight, which usually makes the fruit smaller), and " L " again the second ; of the nine varieties in the main trial, Norfolk Giant was eighth and Baumforth B a poor ninth.

Black Currants.—A new variety trial, including Cotswold Cross, Mendip Cross, Westwick Choice, Wellington Triple X, Baldwin, Boskoop, Seabrooks and Goliath has been planted. A further block of Westwick, Goliath, Baldwin and Triple X, designed for the superimposing of other treatments was also planted. (See also Cultural Measures, below.)

Loganberries and other hybrid berries.—The old collection of different berries has been grubbed, and the best varieties are included in a new trial which also contains some fresh selections.

Strawberries.—The crops of the strain and variety trials were much affected by the frost. All early blossoming varieties such as Royal Sovereign suffered severely, but M.40 once more produced the heaviest crop of the Sovereign selections. The Paxton selections were somewhat less severely damaged, but even the best of them produced less than 2 tons per acre. Huxley and Oberschlesien with their dense foliage and later blossoms, were less affected, and the best strain, Huxley M.44, produced about 3 tons per acre. Oberschlesien M.42 produced 2 tons. The variety Perle de Prague, now popular in Hampshire, has been included in a new trial. Several new stocks of various varieties have been collected for test by the Pathology Section.

An identification key for the most commonly grown strawberry varieties has been completed for publication early in 1945.

Propagation.—The supervision of the *Strawberry* Nuclear Stocks Scheme for the Ministry of Agriculture has been continued. The nurseries, spread over the country from Kent to Cornwall and from Norfolk to Wales, have incidentally provided interesting research observations on runner-bed performance under different soil, climatic and management conditions. The number of nurseries was increased to 15, covering 28 acres. Runner production was generally—and in some cases outstandingly—good ; over two million plants were sent out in the autumn, with nearly another one and a half million more estimated as available for delivery in spring 1945. The percentage of plants rogued for virus or other causes was once more satisfactorily low, averaging only 0·7 per cent. The two newly introduced Huxley clones, M.43 and M.44 have given good results.

The Nuclear Stocks Scheme, having served its purpose of demonstrating that the raising of virus-tested plants under isolated conditions is commercially practicable, is now being changed to a Special Stock Certificate Scheme entirely in the hands of the growers themselves. Stocks of tested and approved parentage, grown under specified conditions of isolation, and maintaining a specified high standard, may be awarded a new Special Stock Certificate on inspection by the Ministry of Agriculture in 1945. The parent stocks approved for 1945 are Royal Sovereign M.40, Huxley M.44 and Oberschlesien M.42.

To ensure a supply of virus-free plants it is desirable that an increasing number of growers should

undertake the raising of Special Stocks of strawberries ; and, to help them, a bulletin " The production of healthy strawberry runners " has been prepared and published (E216).

The first large *Raspberry* cane nursery yielded its first crop of canes ; the varieties are Norfolk Giant and St. Walfried (both clonal stocks) and eight seedlings which have now been distributed to commercial growers. The production in general was somewhat better than was anticipated, especially of Norfolk Giant ; the cane production of one or two varieties was somewhat reduced by the severe drought in the first half of the summer.

Much larger cane nurseries, comprising only six seedling varieties, were planted in the winter of 1943-4, the known "virus-sensitive" varieties being separated as far as possible from the "virus tolerants". All varieties made a good start, and should yield a large crop of canes in the autumn of 1945.

Breeding.—*Raspberries.*—Several further batches of seeds from crossed and selfed flowers were produced and sown, chiefly for the purpose of studying the inheritance of the " sensitive " and " tolerant " reactions to the mosaic viruses, but also with the hope of raising new " sensitives " of the Norfolk Giant type with improved cropping and fruit qualities.

Black Currants.—Trials of a number of new black currant seedlings have been continued. Three seedlings which have proved superior to the best existing varieties in cropping and other characters have been sent to the National Fruit Trials at Wisley.

Strawberries.—Seedlings from crosses between the best existing varieties are being raised in the attempt to breed new kinds possessing vigour, fruit quality and disease resistance. Several promising selections are now undergoing more extensive tests.

Cultural measures.—*Loganberries.*—Further information has been obtained on (i) the effect on cropping of different methods of training the cane and (ii) the best combination of training and spray treatment for the control of Cane Spot. (See also V.B.)

A manurial trial with loganberries has been started, including a comparison of the effects of inorganic and organic manures with and without extra nitrogen in spring, and—on one series of plots—an annual cover crop, Crimson Clover (*Trifolium incarnatum*). Cover-cropping of small fruits is commonly done in the U.S.A., but is new in England. Different methods of training are also included in the trial.

Black currants.—A two-acre block of black currants, for cultural and manurial trials, was planted. On one part a comparison of dung, straw turned-in before planting, and meat and bone meal, has already shown interesting preliminary results.

A pruning method trial comparing close-planted bushes cut down in alternate years with wider spaced bushes normally pruned has been started.

Irrigation.—A strawberry plot has been prepared for an irrigation trial.

Frost damage prevention.—In the trial of strawing methods in relation to frost damage, the most devastating frost occurred before the normal strawing time arrived. No important results on crop were therefore recorded. On one plot where papers were placed over the plants on the evening preceding the frost, a good crop was harvested. The temperature differences recorded at 1 in. above straw and bare ground were less than in the previous trial, averaging only 1·5° to 2·0° colder above straw than above bare ground. This trial will be repeated.

C.—Nuts.—Observations were continued on the time of leafing out, habit of growth, etc. of selected walnuts, and on the damage caused by the May frosts. The frosts killed the young shoots of all trees except a few very late leafing varieties. The trees recovered and made moderate growth but as a result of the frost damage only a few trees, of Mayette and Franquette, bore any crop.

Observations were also made on a collection of young Cobnuts and Filberts.

D.—Horticultural Meteorology.—The routine records were maintained. Studies of temperature as affected by cover crops and by strawing of strawberries were continued as reported above.

Soil moisture studies were continued on bare soil on the meteorological plot and under various cover crops.

Publications during the Year

In Relation to Tree Fruits.

Double-Working and Bridging Incompatible Combinations of Pear and Quince. R. J. Garner. Rep. E. Malling Res. Sta. for 1943 (1944), 80-5. (Eg28.)

Propagation by Cuttings and Layers. Recent Work and its Application, with Special Reference to Pome and Stone Fruits. R. J. Garner. Imp. Bur. Hort. and Plant. Crops. Tech. Comm., **14**, 1944. (Eg29.)

A review of literature is arranged under the headings, (1) propagation by cuttings, which is divided into three sections dealing with source of materials ; (2) handling prior to planting and subsequent

treatment ; and (3) propagation by layers, divided into stooling, layering and marcotting. Division, polyembryony and twinning are briefly mentioned.

The methods in use at East Malling, hardwood, softwood, leaf-bud and root cuttings and the etiolation method of layering, stooling, and tip-laying are concisely described with the aid of drawings.

Lines of procedure likely to prove useful in future research are tentatively suggested. There are subject and author indexes.

Double-Working Overcomes Incompatibility. R. J. GARNER. Nurseryman and Seedsman, March, 1944, No. 2582, pp. 31-34.

Certain pear varieties make unreliable unions when single-worked on to quince and thus are a cause of serious loss to fruitgrowers. Double-working in one operation, here described, is shown to be a practical method of ensuring a satisfactory and lasting union in such combinations. Eighteen varieties said to do better when double-worked, are listed and the variety Beurré Hardy is suggested as an intermediate.

The Influence of Different Pollens on the Growth and Development of Fruit in Apple and Pear. II. Fruit Size and Content in Relation to Fruit Drop. H. M. TYDEMAN. Rep. E. Malling Res. Sta. for 1943 (1944), 31-4. (E206.)

A Preliminary Account of Experiments in Breeding Early and Midseason Apples. H. M. TYDEMAN. Rep. E. Malling Res. Sta. for 1943 (1944), 34-42. (E207.)

The Comparative Susceptibility of High- and Low-Worked Cherry Trees in the Nursery to Bacterial Canker. N. H. GRUBB. Rep. E. Malling Res. Sta. for 1943 (1944), 43-4. (E210).

The Amateur's Fruit Garden. H. M. HUGHES. Rep. E. Malling Res. Sta. for 1943 (1944), 94-9. (E215.)

In Relation to Small Fruits.

Strawberry Runner Raising. The Production of Healthy Strawberry Runners. W. S. ROGERS and J. M. BUTTFIELD. Rep. E. Malling Res. Sta. for 1943 (1944), 87-94. (E216) ; also Fruit-Grower, 1944, **98,** 156, 160, 200, 206, 238, 243 ; and Market Grower, 1944, **22,** No. 35, 12-13, No. 36, 12-13. No. 37, 12-13.

Horticultural Meteorology.

Weather Conditions during 1943. H. C. CHAPELOW and H. M. TYDEMAN. Rep. E. Malling Res. Sta. for 1943 (1944), 49. (H45.)

Miscellaneous.

Outdoor Tomato Variety Trial. H. M. HUGHES and W. C. CORBETT. Rep. E. Malling Res. Sta. for 1943 (1944), 44-6. (E208.)

The Experimental Farm. J. Amos, F. H. BEARD, D. H. HAMMOND, T. N. HOBLYN and H. M. HUGHES. Section I. Rep. E. Malling Res. Sta. for 1943 (1944), 11-14. (E213.)

Orchard Soil Management, Including Water Conservation and Cover Cropping. W. S. ROGERS. Rep. E. Malling Res. Sta. for 1943 (1944), 85-7. (E214.)

General Review of Research Work, with Lists of Papers Published During the Year. Section II. Rep. E. Malling Res. Sta. for 1943 (1944), 15-30. (E217.)

See also IX, Technical Section.

II. STATISTICS AND RECORDS

By T. N. HOBLYN

The publication of the yields of some of the experimental apple plantations at the Station has brought some valuable comparative records from interested growers. While the yields of mature trees in these commercial orchards do not differ markedly from those at the Station, in plantations established during the last 10 years, especially of varieties such as Cox's Orange Pippin, the trees do appear to crop earlier, owing to the lighter methods of pruning practised. The yields of some of the experimental pear plantations at the Station have now been published. (E211.)

Sampling and Variation Studies.—As the Station's programme as a whole extends, sampling problems become more numerous and diverse. The importance of this side of the Section's activities has immensely increased since the war and is not likely to diminish, since a properly designed and accurately tested method of sampling may save labour and at the same time extend the possible scope of an experiment, and give results which are easier to interpret than those of older more laborious methods.

The methods evolved during the past few years for the estimation of the *total crop* of an apple or plum tree without weighing the whole of it, and the *average size* of apple, pear and plum fruits have been described in a single paper now in the press. During 1944, despite small crops, the methods were used with success. A technique for the estimation of fruit colour from samples is still being explored.

An experiment designed to investigate the variation in *Preservative Value* (*P. V.*) *of Hops*, estimated from small samples, was carried out during the year. (See VIII. A.) Variations between samples taken from the same hill and from different hills of a single clone were taken into account. Since the cones forming the samples had first to be selected in the hop garden, then dried in the kiln, resampled, and finally submitted to chemical analysis over a period of several months, several novel sampling problems were encountered, while the whole investigation had to be very carefully planned and organized.

The influence of the personal factor in the *application of sprays* has been examined in relation to the results of spraying experiments for the control of Apple Scab. (See also V. A.)

In the *Red Spider* investigations now in progress (see VI. A), a new technique for recording the infestation on leaf samples is being worked out. The first year's results have been analysed statistically and a modification in the sampling method suggested.

In the Joint Investigations on the *Verticillium Wilt disease of Hops* (see VIII. B), a programme for sampling the soil in healthy gardens and in gardens showing fluctuating and progressive outbreaks of the disease has been drawn up in conjunction with the workers concerned.

Experimental Design.—Plans have now been completed for the two new experimental apple orchards to be planted during the winter 1945-6 and the trees have been budded. (See IA.) These orchards, which are in duplicate on different soils, include trials of the new rootstocks immune to Woolly Aphis. In the design of these trials rootstocks likely to give trees of similar vigour are grouped together, one standard rootstock being common to each of two adjacent groups.

Different varieties and rootstocks are included in the remaining parts of each orchard at appropriate distances of planting, but the trees will generally be allowed to become established before they are used for experiment. However, each section of the orchard is planned for easy adaptation to experimental needs when required.

Several trials in growers' plantations in Essex for the control of Red Spider were planned and carried out in 1944 (see VI. A. and VII. B.), attempts being made to avoid the disturbing effects of spray drift, without a too lavish use of guard trees. A more difficult problem, however, is the design of dusting trials for the control of Apple Blossom Weevil in which the drift is much more extensive, small plots being impossible unless they can be effectively isolated.

Several trials of methods of propagating fruit tree rootstocks, particularly by cuttings, have been planned. (See I. A.) Some of these trials raise new problems in design, since they take place in two stages. In the first, the cuttings of various kinds may receive pre-treatment, e.g., manuring of the mother trees from which they are taken, application of growth substances or subjection to differential preliminary treatment in the greenhouse or frame ; in the second stage the cuttings are planted out, perhaps in more than one medium, in the field. Careful planning is needed to enable the various sources of error to be separated out or confounded in the analysis of the results.

Publication during the Year

The Production History of Three Experimental Pear Plantations at East Malling 1921-43. T. N. Hoblyn. Rep. E. Malling Res. Sta. for 1943 (1944), 71-7. (E211.)

III. PLANT PHYSIOLOGY

By M. C. VYVYAN

Vegetative Propagation.—Further work on the use of growth substances for the promotion of rooting in layers and hardwood cuttings has been carried out in collaboration with Pomology.

Layers.—Previous work carried out by this Section has shown that the rooting in layer-beds of plum rootstocks can sometimes be improved by treatment with indolebutyric acid, applied to the underground portion of the shoots. This method involved the removal of the soil from around the shoots before treatment and its replacement afterwards, further work has therefore been carried out during the current year to test the more practicable method of applying the growth substance in the form of a spray to the above-ground portion of the shoots. (See also I. A.) The results have not been very promising.

Hardwood Cuttings.—A trial has been carried out to test the root-promoting powers of high

and low concentrations of a phenylacetic acid complex (commercial preparation), indoleacetic acid, and tryptophane. The cuttings were grown for a month in a hot frame, and then planted out for a year in the bed of the drained Bradbourne lake. The high concentration of indoleacetic acid showed some effect after the month in the frame, but even this was not perceptible at the end of the year. The phenylacetic complex did not manifest any appreciable root-promoting activity and was anyway inferior to the commonly used indolebutyric acid, a trial with which was available for comparison. (See also I. A.)

The phenylacetic acid complex also proved relatively inactive when examined by the coleoptile test.

Pre-Harvest Drop of Fruit.—Field Trials with Sprays to Control Drop.—A further report on the use of sprays containing synthetic growth substances to control pre-harvest drop of fruit has been published. (F40.)

In view of the continued successes with these sprays reported from abroad and at home, and the marked differences in response found in different varieties and under different conditions, this work is being extended to include new varieties and new methods of treatment. Field trials at East Malling had to be cut down in 1944 owing to the lack of blocks of trees bearing suitable crops, the results of the severe frost in the spring. Several growers, however, have reported successful control of drop by the use of these sprays this season. A paper summarizing the work on these sprays at East Malling, and another reviewing all work on this subject, are being prepared for publication.

Varietal differences in severity and time of pre-harvest drop.—The need for control measures depends on the severity of the drop ; the best time for application depends, in part, on the period when the drop occurs. Both the severity and the period of drop are known to be largely varietal characteristics, though season plays a part. The Station records of dropping in different varieties during past seasons are therefore being examined, and will be supplemented where necessary by observations in the field, to determine what further varieties may be worth spraying and the dates most likely to lead to success.

The Abscission Process.—A study of the abscission processes responsible for fruit drop has been begun, as there is some evidence that differences in the character of these processes may be responsible in part for varietal and seasonal differences in the intensity of fruit drop, and its response to control measures.

Compatibility between Growth Substances and Insecticides and Fungicides.—Work on the compatibility between growth substances and routine spray materials has been continued, in order to explore the possibility of adding these substances to these sprays with a view to reducing pre-harvest drop, or that sometimes caused by the sprays themselves. It has been found this season that the addition of lead arsenate to alpha-naphthalene acetic acid caused no appreciable reduction in the activity of this acid as measured by the coleoptile test.

Publication during the Year

Further Trials with Sprays to Control Pre-Harvest Fruit Drop. M. C. Vyvyan. Rep. E. Malling Res. Sta. for 1943 (1944), 49-51. (F40.)

IV. BIOCHEMISTRY

By W. A. ROACH and B. D. BOLAS

A report has been made to the Agricultural Research Council on the three years' joint work of the team formed by the association of Dr. B. D. Bolas and Dr. D. W. Goodall, of the Research Institute of Plant Physiology, with the Biochemistry Section, and augmented by the Agricultural Research Council to enable it to extend work to potatoes, cereals and other crops of particular importance to the country during the war.

The results of this work indicate that plant analysis, plant injection and quantitative curative experiments under field conditions are both complementary and supplementary to other methods and could be usefully extended to a wide range of crops and to both major and trace nutrient elements. Results obtained from manganese spraying experiments on wheat and peas in the Marshlands of Kent suggest general conclusions that may well have a bearing on making good similar deficiencies in fruit-producing plants. Thus, it has been shown that a deficiency of a trace element (manganese) may bring about an economically important decrease in the crop of wheat and potatoes without producing any visual symptom specific of the deficiency ; there is a suggestion of an optimum concentration of spray ; this optimum concentration seems to vary according to the degree of the deficiency, the relatively high concentration found necessary for the slightly deficient symptomless wheat, being harmful to extremely deficient wheat, for which much lower concentrations are necessary ; more than one spraying seems necessary for wheat ; early spraying seems essential for wheat and relatively late spraying for peas.

A note on improvements in injection methods for diagnostic purposes is in the press.

The work on the mineral content of apple leaves has been continued. The data obtained in 1944 provided no evidence for choosing one type of leaf rather than another in early summer for diagnostic purposes, but suggested that differences in composition between healthy and unhealthy leaf blades tended to be larger in the autumn than at flowering time. To test the possibility that scorched (like senescent) leaves might lose certain nutrients by translocation into the stem, and consequently would tend to give erroneous diagnosis, analyses were made of scorched and apparently healthy leaves from trees in various parts of the Research Station plantations. There was some evidence that the magnesium content of scorched leaves was lower than that of healthy leaves, not only when the trees were deficient of magnesium, but also when they were deficient of potassium. Severely scorched leaves tended to be low in manganese also. The leaf stalks (with midribs) were found to differ in mineral composition from the blades, but there was no evidence to suggest that there were greater differences between healthy and unhealthy stalks than between blades—in fact the blades showed the greater difference in potassium content when this element was low in amount.

Interesting differences associated with rootstock effect were obtained. Leaves of trees on the vigorous rootstock M. XII contained less calcium, more magnesium and probably more potassium than those on the dwarfing rootstock M. IX. The potassium content of leaves from flowering spurs was markedly greater than that of leaves from non-flowering shoots in trees on M. XII, but not markedly different on M. IX. Two papers on the above subjects are in the press.

Evidence of a strikingly clear-cut effect of rootstock on mineral composition has been obtained in the course of joint work with the Pomology Section. (See I. A.) Leaves from a branch into which a rootstock of M. XVI had been inarched proved on analysis to be richer in calcium, strontium, magnesium and potassium, but poorer in iron than corresponding leaves from the rest of the tree, which was on Malling Crab H. Phosphorus content was unaffected. Further work is contemplated to follow up these preliminary results.

The number of cases of potash deficiency diagnosed made it clear that the cessation of potash manuring during the war is now having cumulative effects. This problem seemed to be of serious economic importance to the fruitgrowing industry and therefore received special attention. Evidence has been obtained of a deficiency of both potassium and trace element in apple trees from twenty-seven localities scattered over the counties of Norfolk, Suffolk, Essex, Hertfordshire, Kent, Somerset and Devon. Thirteen of these came from Essex as a result of co-operative work with Messrs. O. G. Dorey and N. Landau of the Essex W.A.E.C. Most of these were diagnosed by a combination of leaf analysis and visual symptoms. Most of the remainder were diagnosed on the basis of the results of analysis of leaf samples sent in by grower Members of the Station. In most of the twenty-seven cases there was die-back of branches and in many of them death of whole trees. The facts suggest a widespread and serious combined deficiency of potassium and one or both of the trace elements manganese and iron. The potassium deficiency seems to have resulted from the cessation of application of potassic manures during the war, and the trace element deficiency is associated with highly calcareous soils or with liming. Most of the iron deficiencies were examples of true deficiency, as opposed to those in which normal or abnormally high amounts of iron are present in the leaf in an unavailable form. The trouble is so serious that, unless speedy and appropriate action is taken, large numbers of these trees seem likely to die, because, even after potassic manures become available for fruit, some time must elapse before these slow acting manures can exert their effect. The result of a few preliminary tree injections with potash salts offer some hope of supplying the trees' needs in the mean time.

Encouraging preliminary results have been obtained from spraying manganese deficient cherry trees with a strong (up to 10 per cent.) solution of manganese sulphate in winter. These are being followed up in the hope of obtaining a method that many growers would prefer to the solid injection method, which entails undesirable mechanical damage to the trunk.

Evidence has been obtained from analysis, leaf painting and branch injection of an iron deficiency in sweet cherries, showing symptoms different from those so far described for this deficiency. There were also indications of other deficiencies (manganese and zinc).

The leaf painting method just mentioned is being tested for diagnostic purposes.

Publications during the Year

The Present Position Regarding the Diagnosis of Mineral Deficiencies in Fruit Trees by Plant Analysis and Plant Injection. W. A. Roach. Rep. E. Malling Res. Sta. for 1943 (1944), 99-103. (K41.)

A Review of our Knowledge of Mineral Deficiencies in Fruit Trees. S. G. Thompson. Rep. E. Malling Res. Sta. for 1943 (1944), 103-6. (K42.)

Abnormal Ripening of Cherries. S. G. Thompson. Rep. E. Malling Res. Sta. for 1943 (1944), 51. (K43.)

V. PLANT PATHOLOGY

By R. V. HARRIS

A.—Diseases of Tree Fruits.—*Bacteriosis of Plum and Cherry Trees* (*Pseudomonas morsprunorum* Wormald.)—The new spraying trial on young plum trees yielded inconclusive results through lack of infection.

The work on the control of this disease on sweet cherry was prepared for publication. Two sprayings of Bordeaux mixture, one at 10 - 15 - 100 in October and the other at 6 - 9 - 100 just preblossom, gave very good control on the susceptible Bigarreau de Schrecken variety over a four-year period.

Silver Leaf (*Stereum purpureum* Pers.).—*Injection of Plum Trees with Fungicide.*—Observations were maintained on Victoria trees injected with 8-hydroxyquinoline and related chemicals as solids for the direct control of this disease.

Wilting of Plum Shoots in Layer Rows.—The fungus (*Cylindrocladium scoparium*) causing this disease was described (C200). (See also I. A.)

Apple Scab.—(*a*) Additional evidence was obtained on the validity of a method for measuring the severity of infection on apple foliage. Useful application of the method was demonstrated in a spraying trial in which the crop had been destroyed by frost.

(*b*) Studies on the effect of spraying apple trees in bloom were in abeyance in 1944 because of frost damage to blossoms.

(*c*) Field trials of new fungicides, in collaboration with the Plant Protective Chemistry Section (see VII B), were similarly hampered, but again indicated the high fungicidal value of an organic mercurial compound.

(*d*) The results of a preliminary collaborative investigation with the Statistics Section (see II) on the influence of the personal factor in spraying, and on tree-to-tree variability in the degree of control were prepared for publication. Specially thorough, but possibly uneconomic, spraying, as compared to ordinary routine spraying, increased control and decreased variability.

Apple Canker.—Though adequate local sources of inoculum were ensured in the field spraying trial, insufficient cankers were formed to provide a basis of comparison for the spray programmes tested. This was probably due to the prevalent dry weather.

B.—Diseases of Soft Fruits.—*Raspberry Virus Diseases.*—The tests of six new seedlings, carried out in 1943, showed that four were virus-free, but that three of them were tolerant of infection with Mosaic 2 and that they were therefore potential " carriers ". Tests of Lloyd George stocks did not result in the discovery of a virus-free stock and suggested the existence of an unsuspected virus " carried " by this variety and producing leaf-curling and dwarfing symptoms on Baumforth's Seedling B.

Tests to determine the virus reactions of four additional seedling varieties and further work on the reactions of Norfolk Giant were started.

Ministry Certification Scheme for Norfolk Giant Raspberry.—Throughout the season collaboration was maintained with the Ministry of Agriculture and Fisheries in the formulation and introduction of this scheme. Numerous surveys were made in Kent and in the Norfolk area (by courtesy of Mr. P. E. Cross) and data were collected on disease status, expression, and spread.

Raspberry Diseases Investigation in Scotland.—The establishment of this investigation by invitation of the Agricultural Research Council in November of last year (1943) with local headquarters at Botany Department, University College, Dundee, has enabled a considerable widening and development of research into the causes and control of raspberry " degeneration " diseases. The main objective in 1944 was to explore the disease situation in Scotland, particularly in the intensive raspberry growing areas of Angus and Perthshire, in order to assess the relative importance and distribution of the individual diseases concerned. Much valuable data for this survey was made available by courtesy of the Department of Agriculture for Scotland.

Virus testing and analytical work were also started in conjunction with the programme at East Malling (see above), and material was collected for the experimental work projected for 1945, particular attention being paid to the rôle of the ubiquitous wilding raspberries in the disease situation generally.

As a preliminary to further attempts to determine the insect vectors of raspberry viruses, a survey of the populations of Hemipterous insects on raspberries was made at four centres in the Strathmore area (with the assistance of the Entomology Section) and an insect trap was maintained throughout the season in conjunction with the Rothamsted Experiment Station.

To explore the possibility of maintaining basic stocks of healthy planting cane in comparative

olation, but readily accessible from the concentrated growing areas, land was acquired for experiental Cane Nurseries in the highland district of south-east Perthshire and on the hills of the Carse of owrie. The administrative part of this scheme was undertaken by the Edinburgh and East of otland College of Agriculture. The investigators also collaborated with the Department of Agriulture for Scotland on the proposed re-instatement of the Department's scheme for the certification f raspberry planting stock.

Raspberry and Loganberry Cane Spot (*Elsinoë veneta* (Burkh.) Jenkins.)—(*a*) *Seasonal survey.*—rial observations were started to determine the relation between weather conditions and the asonal development of the disease on raspberry and loganberry.

(*b*) *Control on Loganberry.*—While the old spraying trial, now completed, showed that this sease can be controlled by suitable training of the new canes, coupled with spraying, it revealed at at least one of the sprays caused damage. A new trial was therefore started using the same ants, to test the safety and effectiveness of weaker sprays. This will not yield results until any mulative effect of the old treatments has disappeared and the data obtained in 1944 therefore wait interpretation in the light of further observations. (See also I. B.)

Strawberry Virus Diseases.—Testing and maintenance of selected stocks of commercial varieties as continued. Among the newer varieties tested Early Cambridge was found to be sensitive and erle de Prague intermediate in reaction to Yellow-edge.

A degeneration of stocks of Huxley's Giant was shown to be graft transmissible and, as no visible athogen has been discovered, that disease is concluded to be of virus origin.

Work on the separation of viruses from naturally occurring complexes by means of the aphis ector was continued and extended to include the virus or complex that causes a degeneration in uxley. The properties of the viruses already isolated were further studied with a view to their lentification and the elucidation of their relative importance. So far, two similar " non-persistent " iruses (or two strains of one virus) and two " persistent " viruses have been isolated. One or other f the " non-persistent " viruses has been isolated from each of the types of infected plant studied, hile one of the persistent viruses appears to be associated with Severe Crinkle infections and the ther with Yellow-edge infections.

Strawberry Verticillium Wilt.—Observations were continued on outbreaks of this disease in Kent nd Cambridgeshire.

Artificial inoculations were made to determine (i) the relative susceptibility of *Fragaria* species nd selected cultivated varieties to *V. Dahliae* Kleb. and *V. albo-atrum* R. and B. and (ii) the relative athogenicity of each of these fungus species.

Experiments to study the incidence of Wilt in relation to propagation by runners were started.

Strawberry Leaf-Blotch (*Zythia Fragariae* Laibach.)—The perfect stage of the fungus causing his disease was found in pure cultures and on infected plants, and proved to be a species of *Gnomonia.* noculation experiments on leaves of strawberry plants gave positive results.

C.—Diseases of Hops.—(See VIII. B.)

D.—Miscellaneous Investigations.— *Verticillium Wilt.*—See Hops (VIII. B) and Strawberry V. B above.)

Nut Drop.—An account of this disease was published (C201).

Publications during the Year

A Cylindrocladium as the Cause of a Shoot Wilt of Varieties of Plum and Cherry used for Rootstocks. H. Wormald. Trans. Brit. mycol. Soc., 1944, xxvii, 71-80. (C200.)

A *Cylindrocladium* has been isolated from the underground parts of wilted layer shoots of plum, cherry, peach, and apricot, and from plum cuttings.

In its morphology the fungus conforms to *Cylindrocladium scoparium* Morgan. Its habit in cultures, however, is quite distinct from the fungus, referred to *C. scoparium*, isolated by Massey from roses.

Experiments have shown that the typical symptoms of the disease can be induced by inoculating the lower leaves of shoots on plum stools in pots and then covering them with soil.

Measures for the control of the disease are suggested.

Nut Drop. A Disease of Cultivated Hazel Nuts. H. Wormald. Rep. E. Malling Res. Sta. for 1943 (1944), 56-8, and Gdnrs' Chron., 1944, cxv, 60-1. (C201.)

Silver Leaf and Papery Bark in Apple Trees. H. Wormald and H. B. S. Montgomery. Rep. E. Malling Res. Sta. for 1943 (1944), 51-2. (C202.)

Verticillium Wilt of Plum. W. G. Keyworth. Rep. E. Malling Res. Sta. for 1943 (1944), 52-4. (C203.)

Cherry Scab (Fusicladium Cerasi (Rabenh.) Sacc.) in Kent in 1943. M. H. MOORE. Rep. E. Malling Res. Sta. for 1943 (1944), 54-6. (C204.)

Norfolk Giant. A Reliable Raspberry for the Present Day. R. V. HARRIS. Rep. E. Malling Res. Sta. for 1943 (1944), 108-10; also under change of title in Fruit-Grower, 1944, **98,** 81-2 and **98**, 98, and Market Grower, 1944, **22,** 7-8 and **22,** 16-17. (C206.)

Why does my Spray Programme for Scab Break Down? M. H. MOORE. Rep. E. Malling Res. Sta. for 1943 (1944), 107-8. (Q36.)

VI. ENTOMOLOGY

By A. M. MASSEE

A.—Tree Fruits.—*Apple Blossom Weevil.*—Studies on the life history have continued and given results in very close agreement with those obtained the previous year. Observations indicate that the majority of the weevils hibernate above ground level.

Control measures have centred around the most promising insecticides tested in 1943. Dusts composed of 5 per cent. D.D.T. and 3 per cent. 666 have given consistently good results in laboratory trials, 1 per cent. rotenone dusts made up from lonchocarpus, high grade and low grade derris roots and derris extracts all proved ineffective as did 5 per cent. dinitrocyclohexylphenol. (See VII. A.)

In field trials a 1 per cent. rotenone dust appeared to give no control. On a small scale 5 per cent. D.D.T. reduced capped blossoms by 90 per cent.

Results of a similar order were obtained in Essex where field trials were also carried out. (See VII. B.)

Experiments have shown that good kills of weevils hibernating in sack bands can be obtained by routine tar washing.

Woolly Aphid Parasite.—Experiments to overwinter the parasite in cold storage are being continued. The parasites kept in cold storage last winter emerged successfully last May. A progress report on this investigation to date has been published recently. (D178.)

Fruit Tree Red Spider.—Life-cycle. A detailed study of the life-cycle of the Fruit Tree Red Spider is being made in the field and laboratory. Such aspects as the different stages of the animal, the number of generations, the oviposition of summer and winter eggs, and the rate of increase of the mites, are being studied.

Alternative hosts. The alternative host plants of the mite—in addition to cultivated fruits—are being examined to determine their importance.

Migration phase. The importance of the migration phase of the mite is being investigated in the orchard, and a technique has been evolved for this purpose.

Predaceous insects. A number of predaceous insects and mites are being studied with a view to determining their relative importance in the possible biological control of this pest. Certain species are receiving special attention.

Field spraying trials. Spraying trials are in progress to determine the value of certain winter washes against the eggs of the mite. (See II and VII. B.)

In addition, tests of modified methods of technique for recording the results of these trials are being made. (See also II.)

Laboratory tests of insecticides on eggs of Fruit Tree Red Spider. A new method of rearing mites on young apple seedlings is being worked out to facilitate testing of summer and winter eggs of the mite under laboratory conditions.

Apple Capsid Bug.—Field spraying trials are in progress to test certain ovicides against this pest. (See VII. B.)

B.—Small Fruits.—*Strawberry Insects.*—The fauna of the cultivated strawberry is being studied with special reference to the aphides. Two species of beetles (*Tachyporus obtusus* and *T. hyphorum*) have been found to be common predators of *Capitophorus fragariae* Theo. and a note concerning them has been published. (D181.)

Strawberry Aphid Survey.—Population counts have been continued from May to August on selected farms in Hampshire, Worcestershire, Isle of Ely and Kent. The duration and intensity of the migrant form was again recorded.

Regular samplings of population have continued on all Research Station plots and the nuclear stocks situated in Kent.

Vaporized Nicotine Treatment for Strawberry Aphid Control.—Lack of experimental equipment reduced this project to treatment by a commercial machine. All Nuclear Stocks in Kent and important plots on the Research Station were treated during the summer months.

An experimental gassing machine has been designed and is being built.

Gooseberry and Currant Aphides.—Further work has continued on the biology of these aphides.

Rubus insects.—The weekly survey is being continued on two plots of raspberry of which one sprayed at regular intervals. The insect population of the two plots varies considerably.

Reversion of Black Currant.—The tests made with the Black Currant Gall Mite as a possible ector of reversion in 1943, have proved conclusively that the mite is a vector of reversion. All the oculated plants reverted while the controls remained healthy.

Control of Tarsonemid Mite.—A mite population is being built up on a series of experimental ants to enable further tests of insecticides to be made.

Black Currant Leaf-curling Midge.—A plot of black currants is being planted to enable the life-cle of this obscure insect and its control to be studied close at hand. A study of the overwintering coons of the midge is being made.

Systematic Study of the Phytoptidae.—Specimens sent in by economic entomologists have been entified.

The British Tetranychidae or Red Spiders.—Specimens from various sources have been investigated d identified.

C.—Insect Pests of Hops. (See VIII. C.)

Publications during the Year

otes on some Interesting Insects Observed in 1943. A. M. Massee. Rep. E. Malling Res. Sta. for 1943 (1944), 58-65. (D177.)

rther Notes on the Woolly Aphis Parasite (Aphelinus mali Hald.). A. M. Massee. Rep. E. Malling Res. Sta. for 1943 (1944), 65-7. (D178.)

aterpillars of the Winter Moth Group and of other Moths. A. M. Massee. Rep. E. Malling Res. Sta. for 1943 (1944), 111-2. (D179.)

ediculopsis graminum. A Species of Tarsonemidae new to Britain. A. M. Massee. Ann. Mag. nat. Hist. 1944, **11**, 190-4. (D180.)

An account is given of the occurrence of a tarsonemid new to Britain, together with a translation the original description of the mite.

achyporus (Col., Staphylinidae) larvae preying on Aphides. G. H. L. Dicker. Ent. mon. Mag. 1944, **80**, 71. (D181.)

This records the presence of adults and larvae feeding on the Strawberry Aphid in Southern and idland Counties. In 1943 larvae of *T. hypnorum* and *T. obtusum* were more numerous than any ther species.

he Black Currant Leaf Curling Midge (*Dasyneura tetensi* Rübs.) A. M. Massee. 1944, Agric. Bulletin, **2**, 52-4. Issued by the Essex War Agricultural Executive Committee. (D182.)

A review is given of the life-cycle and control measures of this important pest of soft fruit.

VII. PLANT PROTECTIVE CHEMISTRY

By H. SHAW

A.—Laboratory Investigations.—Chemical.—Work on the standardization and analysis of pest ontrol products has been continued. Additional members of the group of thiuram sulphides and elated substances have been synthesized and the stability and reactions of this type of compound re being studied in relation to fungicidal properties. The physical-chemical problems associated vith the use of D.N.C. washes are being investigated.

Ovicides.—Several changes have been made in the technique of the biological assay of ovicides, using eggs of *Aphis pomi* as test organism. Most important of these is the introduction of alcoholic potash as solvent for removing the eggs from the twig ; the method of collecting the biological material from the field has been improved and the procedure for counting eggs and aphides simplified. An account of the modified technique has been published. (Q37.)

Of twenty-two nitrophenols tested against *A. pomi* eggs, only other members of the 2 : 4-dinitro-6-alkylphenol series approached 3 : 5-dinitro-*o*-cresol (2 : 4-dinitro-6-methylphenol) and 2 : 4-dinitro-6-*cyclo*hexylphenol in toxicity and none was superior. Compounds of the 2 : 6-dinitro-4-alkylphenol series and 2 : 4-dinitro-α-naphthol were all less toxic, while none of the ten mono- or trinitrophenols tested was at all toxic even at 0·2 per cent. Of nine heterocyclic bases and seven cyclic amines only phenanthridine at 0·2 per cent. and carbazole at 0·1 per cent. were highly toxic. Most of the above compounds were prepared by the Chemical Research Laboratory of the D.S.I.R. A preparation containing the β-thiocyanoethyl esters of mixed higher fatty acids compared very unfavourably with

others containing a similar amount of β-butoxy-β′-thiocyanodiethyl ether. *p*-Chlorophenol was much more toxic than *o*-chlorophenol, and D.D.T. at 2·0 per cent. was almost inactive.

A low-temperature tar distillate neutral oil in sulphite lye emulsion appeared to be as good a medium for the application of dinitro-cresol as was ten times the volume of spindle oil.

Contact Insecticides.—Three dusts made up respectively from lonchocarpus, high grade, and low grade derris and each containing 1 per cent. rotenone gave very poor results against Apple Blossom Weevil. A 5 per cent. dinitro-*o*-cyclohexylphenol dust was ineffective, whereas D.D.T. and benzene hexachloride (666) dusts showed great promise. (See VI. A.)

Fungicides.—Several modifications in the method of testing have been made.

Further work has been done on organomercurials, and the study of the mechanism of the fungicidal action of thiuram sulphides and related substances has been resumed. Among a number of amines tested, long-chain primary or secondary derivatives were much more toxic than short-chain tertiary, or cyclic compounds. The hydrochlorides were about as toxic as the free amines.

B.—Field Investigations.—The loss of crop resulting from the severe May frost seriously interfered with field trials. In particular, trials either projected or in progress of D.D.T. against *Apple Sawfly*, *Plum Sawfly*, and *Codling Moth* had to be abandoned.

Insecticide Trials.—*Raspberry Beetle.*—On loganberries in 1944, excellent control followed two applications of D.D.T. either in the proprietary form of " Guesarol E " or as a laboratory preparation. The results were at least equal to those following sprayings with an unusually high concentration of rotenone. A report of the two years' results of this trial is in the press.

Apple Capsid.—The effect of time of application on control by a D.N.C.-petroleum wash was investigated on a 3-acre plot where Capsid had proved difficult to control. The crop was very light, the incidence of Capsid was low, and the results were inconclusive. (See VI. A.)

Fruit Tree Red Spider.—In the A.R.C.-Pettar-Ace trials in Essex, a D.N.C.-petroleum wash was compared with a straight petroleum miscible-oil wash, each applied in January, February and March. (See VI. A.)

Apple Blossom Weevil.—In these same trials, a dust containing 5 per cent. D.D.T. was compared with one containing 1 per cent. rotenone. (See VI. A.)

Fungicide Trials.—*Apple Scab.*—In the virtual absence of fruit, little additional information was forthcoming from the trial started in 1941. For the same reason it was not possible to examine further the apparent loss of crop resulting from the use pre-blossom of certain preparations of phenyl mercury chloride. (See V. A.)

Publications during the Year

Some Modifications of Procedure when using Eggs of *Aphis pomi* (De Geer) for the Biological Evaluation of Insect Ovicides. P. H. Tuft. Rep. E. Malling Res. Sta. for 1943 (1944), 67-8. (Q37.)

VIII. HOPS

A.—Varieties and Cultivation Trials.

By F. H. BEARD

Commercial Varieties.—The first season's crop records from the clonal Golding trial showed differences between the five late selections, but there was no difference between the two early selections. The crop from each selection was pressed separately, and samples of the dried hops were analysed by Dr. T. K. Walker and his assistants at Manchester; material was reserved for brewing tests to be carried out by Professor R. H. Hopkins at Birmingham for the Institute of Brewing.

An extensive collection of Fuggle hills obtained from various sources is being established. It is hoped to select a limited number of these for further trial.

Variation in Preservative Value.—Two of the East Malling Clonal Fuggles have been utilized for an experiment designed to measure any variation in P.V. that may occur between individual hills of the same clone. (See also II.) This has involved the picking, drying and analysing of 192 separate samples.

New Varieties.—The testing of the new seedling varieties raised by Professor Salmon has been continued. The crops from some 140 varieties were picked and dried separately to enable the yield to be estimated and to provide material for analysis and brewing tests where required. Samples of forty-eight varieties, the majority of them not previously tested, were placed in air-tight glass jars for subsequent determination of P.V. by Dr. Walker. Four varieties, one of which is resistant to *Verticillium Wilt*, have been submitted for brewing trial.

The systematic testing of the seedlings for resistance to *Verticillium Wilt* continues. (See B below.)

This work is being carried out in collaboration with Professor E. S. Salmon, who has published a report (B50).

Cultural Trials.—The trial of distance of planting and severity of pulling on Brewer's Favourite has been concluded and an account of the trial appears on p. 92 of this Report. Different times of " dressing " or cutting, again had no effect on the cropping, though there was as usual great variation in the forwardness of the bine throughout the growing season. Cutting of the bines just below the breast wire (necessary with machine picking) caused no reduction of crop in 1944. The season's results from the trial with the very vigorous variety O147 again indicated that this variety can make full use of very wide spacing (7 ft. by 9 ft.).

Manurial Trials.—With O147, nitrogen at the rate of 73 lb. per acre gave lower yields than nitrogen at 219 lb. per acre, as in previous years. Thus a reduction in the amount of nitrogen is not a satisfactory method of reducing the vigour of a very strong growing variety. Cropping is reduced without any apparent diminution of bine growth.

Propagation Trials.—The comparison of strap-cuts and natural runners has been repeated, but with a variety different from that used in 1943. Again there was no difference in the number of rooted sets produced, nor, on this occasion, in size of set.

The first season's results from a trial designed to measure varietal and seasonal variation in the number of rooted sets produced from strap-cuts, showed that definite varietal differences exist, and also indicated that strap-cuts from young (1 year from planting) hills produce a higher percentage of rooted sets than strap-cuts from mature hills.

B.—Hop Diseases.

By W. G. KEYWORTH

Verticillium Wilt (*Verticillium albo-atrum* R. & B.). (a) *Survey.*—During 1944, three outbreaks were newly reported direct to the Research Station. One of these was a progressive outbreak of at least three years' standing. In addition, eight previously unknown outbreaks were notified during the Ministry of Agriculture inspections for the certification of Wilt-free gardens. Four of these were in Kent and four in the West Midland area ; none was apparently of the progressive type.

(*b*) *Resistance trials* of the Wye Seedling varieties were continued and one further variety was selected as showing promise. Varieties selected in the two previous seasons were tested in small scale farm trials in several localities and their resistance appeared to be maintained.

(*c*) *Pathogenicity studies.**—Comparative soil infections of field plots with diseased bine from " Progressive " and " Fluctuating " outbreaks respectively, yielded differences in Wilt incidence. In parallel stem inoculations with pure cultures, again no differences in pathogenicity were recorded (see Annual Report, 1943, V. D) and the evidence for differing pathogenic strains of *V. albo-atrum* R. & B. is therefore as yet by no means conclusive.

(*d*) *Soil related to Wilt severity.*—The above soil-inoculation experiment was duplicated on two contrasted types of soil and the average Wilt severity on one type differed considerably from that on the other. This experiment was supplemented by a similar experiment using soil in tubs, and great differences in Wilt incidence were noted as between the infected plants on the two soil types.

(*e*) *Fluctuating Wilt.*—Symptom expression in relation to infection was studied in several commercial gardens. Tests of cuttings from one such garden showed the fungus to be present, both in cuttings from hills previously showing symptoms, and to a less extent in cuttings from nearby and apparently healthy hills.

Phytophthora Root Rot (*P. Cactorum* Leb. & Cohn).—Further studies were made of the isolates obtained from a number of outbreaks of this disease in widely separated localities. All the isolates appeared to be morphologically identical and it is thus probable that this fungus is a common soil inhabitant of hop gardens.

Hop Canker.—An abnormal form of hop canker which affects the bines at some 6-18 inches above soil level was seen in many localities. Experiments indicated that a species of *Fusarium* is the causal organism.

Virus Diseases.—(*a*) *Nettlehead.*—Observations were made on the plants of eleven Wye varieties grafted to Nettlehead-affected plants in 1943. Of these varieties, all but one showed Nettlehead symptoms. Further grafting tests were made in 1944.

(*b*) *Mosaic.*—Routine tests of male hops and a number of Wye varieties were continued. Patch-grafting was tested as a convenient method for such routine tests, and satisfactory transmissions obtained.

* Work by I. Isaac.

Ministry Certification Scheme.—Collaboration with the Ministry of Agriculture and Fisheries in the working and development of the Ministry's Scheme for the certification of hop gardens as sources of healthy planting stock was continued during this, its second year.

C.—Insect Pests of Hops.

By A. M. MASSEE

Economic Vectors of Hop Virus Diseases.—Tests made with all stages of the Hop Shy Bug (*Calocoris fulvomaculatus* De Geer), collected from a commercial garden in 1943, did not transmit mosaic or nettlehead.

Hop Eelworm.—A technique has been devised to enable the eelworm (*Heterodera rostochiensis* Woll.) to be tested as a possible vector of mosaic and nettlehead. Attempts to establish colonies of eelworms on hop roots growing in observation boxes have proved successful.

The free living species of eelworms are being studied.

Publications during the Year

Intensive Methods for the Propagation of Hops : A Plea for Special Hop Nurseries. F. H. Beard. Rep. E. Malling Res. Sta. for 1943 (1944), 112-14. (B48.)

Propagation Trials with Hops. 1. The Effect of Treating Cuttings (Strap-cuts) with a Growth Substance before Planting. F. H. Beard. Rep. E. Malling Res. Sta. for 1943 (1944), 68-70. (B49.)

Twenty-seventh Report on the Trial of the New Varieties of Hops. E. S. Salmon. August, 1944.

1. Of the 101 varieties (new and commercial) tested, three New Varieties cropped at the rate of over 28 cwt. to the acre, six at over 25 cwt., and thirty-four at 20 cwt. or over.

2. For the second season a number of Anglo-American hybrid varieties were grown with only one bine to the string ; heavy yields were obtained, twenty-two varieties cropping at the rate of over 20 cwt. to the acre. Trained in this way, " Bullion Hop " (Q34) and " Brewer's Gold " (C9a) gave in the dry growing season of 1943, 29 cwt. and 28 cwt. respectively. Both these varieties definitely belong to the " One-bine class ", and it is strongly recommended that they are grown commercially in this way.

3. The average yield per acre of " Brewer's Gold " over 15 years at East Malling Research Station now stands at 26 cwt. and of " Bullion Hop " over 9 years at 26¼ cwt.

4. The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 62 to 118.

5. Analyses are given of a number of growths of the New Varieties produced commercially in Kent and Worcestershire. The preservative values of these exceed those of the same varieties grown at East Malling Research Station and at Wye College. One growth of " Brewer's Gold " from the parish of Lindridge, Worcestershire, proved exceptionally rich, showing 11·14 per cent. α-resin and 10·96 per cent. β-resins, giving a P.V. of 111, which is double that of the commercial variety " Mathon ". A sample of " Malling Midseason " (BB28) grown at Tenbury, Worcestershire, gave a higher analysis than that from East Malling Research Station, Kent.

6. OM26, a bud sport of the " Nonsuch Hop " (OB53) was richer than its parent by 2·50 per cent. α-resin and 2·63 per cent. β-resins. This superiority of a bud sport in the production of soft resins has now been shown for nine consecutive seasons ; it is suggested that research should be directed to ascertain whether similar bud sports may exist in the various commercial varieties.

7. Information is given on the valuations accorded by the Hops Marketing Board to certain growths of the New Varieties. Although there is more brewing value in the New Varieties, these are still being pegged down to prices fixed for Goldings. A fairer and more scientific method would be to establish a special class for the New Varieties (which might be called the Resin Class) and to base valuations on preservative value and known performance in brewing trials. Such valuations have been made by Messrs. William Younger & Co. Ltd., on some of the New Varieties as grown at East Malling Research Station, the brewing values of which were assessed, per cwt., as follows : OM26, £36 ; " Brewer's Gold ", £28 12s. ; " Bullion Hop ", £28 7s. ; " Nonsuch Hop ", £27 13s. ; " Malling Midseason ", £24 15s. ; " Quality Hop ", £24 11s. ; " Brewer's Stand-by ", £24 4s.

8. It is pointed out that since brewers have called for 6,000 cwt. of the New Varieties annually, some 200 acres of these need now to be planted (in addition to the existing 100 acres), in order to meet the demand. It is suggested that part of this new acreage could be found if a better hop than the Fuggle were planted on some of the acreage now occupied by that variety. In this connection it is pointed out that there is an urgent need for the establishment of an Experimental Station in the

Weald, where the approved New Varieties can be tried on Fuggle soil, so that one or more of the most suitable of these can be selected.

9. The results of recent Brewing Trials are reviewed. In the first series the New Varieties were distributed to sixteen firms of brewers ; twelve returned a favourable report, two an unfavourable one, while the verdict was doubtful in two cases. One brewer made the valuable suggestion that the merchant should be required to provide an analysis with the hops he supplies. The rate of loss of P.V. could be assessed from the data which have been communicated from the laboratories of Messrs. William Younger & Co. Ltd. In the second series of brewing trials, carried out by the Institute of Brewing, two of the newer varieties were preferred to the Oregon hop that was used. In the third series carried out by Messrs. William Younger & Co. Ltd., the authors of the Report wrote in their Summary : " There is no doubt whatever that the hops enumerated above (certain of the New Varieties) have a far higher brewing value than the best commercial Golding ; they should therefore command a higher valuation, thus encouraging growers to replace worn-out commercials with the New Varieties, to the ultimate benefit of the brewing industry as well as to the grower himself."

IX. TECHNICAL SECTION

By H. B. S. MONTGOMERY

During 1944 the Technical Section has dealt with the majority of the greatly increased number of advisory enquiries that are received by the Research Station, by letter, telephone and personal enquiry. It has thus spared the research workers from the constant interruption to their work that such enquiries can cause. A relatively small number of enquiries are of a specialist nature and need to be dealt with by the research worker concerned. In addition to these contacts with growers and amateurs and to printed articles, the section has worked through the County Officers by supplying them with photographs and ciné films and by assisting with the organizing of conferences, discussions and farm walks. One of the most important tasks of the past year has been the assistance given to the Ministry of Agriculture in rewriting the fruit bulletins, the major part of which has been done by this Section. The new bulletins on Apples and Pears and on Tree Raising are now nearing completion.

Publications during the Year

Amendments to Spray Calendar, 1942. Rep. E. Malling Res. Sta. for 1943 (1944), 114. (Q35.)

Summer Pruning Cordon Apples. H. B. S. Montgomery. Amateur Gardening, 1944, **60**, 10. (E209.)

This is a popular account of the two methods of summer pruning cordon apples that have been under trial at East Malling.

Cordon Culture of Apples. H. B. S. Montgomery. Rep. E. Malling Res. Sta. for 1943 (1944), 77-80. (E212.)

Section III

RESEARCH REPORTS

POMOLOGY

A NOTE ON THE USE OF SYNTHETIC GROWTH SUBSTANCES ON PLUM ROOTSTOCK LAYER BEDS

R. J. GARNER (*East Malling Research Station*)
E. S. J. HATCHER (*Research Institute of Plant Physiology*)

Introduction.—Labour costs in the vegetative propagation of fruit tree rootstocks by the etiolation method of layering, described by Knight *et al* (1928), Feilden and Garner (1940) and Garner (1943), are comparatively high. Even in large scale production it has not proved possible to reduce this cost appreciably and therefore any promising variation in technique, or any additional treatment which might increase production without proportionately increasing the cost, is worthy of investigation. For this reason the many excellent results obtained by the treatment of cuttings with synthetic growth substances have encouraged enquiry into the use of such compounds for promoting root development on layers.

Sinha (1942) treated layers with varying concentrations of indolebutyric acid at four different stages of growth, the varieties used being the plum rootstocks Malling Myrobolan B (*Prunus cerasifera*) and Pershore (*Prunus domestica*), and the pear rootstock Malling C8 (*Pyrus cordata*). Incisions were made at, or near the base of the shoot into which was inserted lanolin paste containing the growth substance. The earliest treatment was given before earthing, at which time the incisions were made close to buds on the laid shoots. In later applications incisions were made at the base of the new shoots when it was necessary to uncover and re-earth. Of the three varieties only the ready rooting Myrobolan B responded favourably to treatment and then only from the later applications made when the shoots were well grown. The author concluded that improved methods would have to be sought, not involving unearthing the layers, if growth substance treatment was to become commercially practicable.

Some results obtained with other types of plants are of relevant interest. With mango Thakurta and Dutt (1941) observed increased rooting following applications of growth substances at the marcot position, though, as in Sinha's experiments, treatment involved wounding each shoot. By contrast Pearse (1937) sprayed young intact tomato plants with dilute solutions of indolebutyric acid and reported that while such treatment did not influence the total amount of dry matter assimilated it did increase the proportion laid down as root. This led Garner (1944) to suggest that repeated spraying with growth substance might increase the rooting of fruit tree layers, and the following experiments with plum rootstocks were designed to test for such an effect which, if found, could be employed with considerable benefit in large scale production of rooted layers.

Experiments in 1943.—Trial 1.—The above-ground parts of a 15-year-old layer bed of the plum rootstock Brompton (*Prunus domestica*) were sprayed with an aqueous solution of α-naphthalene acetamide. The spray was applied on two occasions, early and late, and to other plots, on both occasions at half-strength, with the water controls this giving four treatments, namely :

(i) Early spray on 4th June, 20 parts per million solution.
(ii) Late spray on 20th August, 20 parts per million solution.
(iii) Double spray, 4th June and 20th August, 10 parts per million solution.
(iv) Water spray controls, 4th June and 20th August.

Periodic observations during the summer revealed no discernible effect of the growth substance sprays on foliage or shoot growth. In November the layers were uncovered and their rooted shoots removed and counted. There were no differences of statistical significance between the various treatments.

Trial 2.—A similar layer bed of Brompton plum was sprayed with a 20 parts per million solution of α-naphthalene acetic acid on 12th June, the control plots receiving a water spray. Again there

was no noticeable effect upon foliage or shoots. In November the layers were harvested and in this case statistical analysis revealed a significant increase (P=·05) in the production of first grade rootstocks due to growth substance. It must be noted, however, that the general level of cropping in this experiment was much below normal and for this reason undue importance should not be attached to the result.

Trial 3.—A 15-year-old layer bed of the plum rootstock Myrobolan B (*Prunus cerasifera*) was sprayed on 31st July in three ways :

(i) 100 parts per million solution α-naphthalene acetic acid.
(ii) 50 parts per million solution α-naphthalene acetic acid.
(iii) Water only.

There was no effect of growth substance either on the shoots or on root development.

Experiment in 1944.—A large-scale trial was conducted on a 3-year-old layer bed of the plum rootstock Myrobolan B using both sprays and dusts applied at fortnightly intervals from 2nd May to 13th June, during which period root initials are thought to make their appearance in this variety. Lange (1942) working with a range of stooled apple rootstocks had found that root initials first appear in most varieties towards the end of May or early June, and continue to appear up to the middle of July. No comparable figures are available for plums, but it may perhaps be assumed that root initials appear somewhat earlier in the season in mounded shoots of the plum rootstocks, especially in the Myrobolan selection which starts growing very early in spring.

Lay-out.—Two parallel layer rows each 750 feet long were divided into lengths of 15 feet, 10 feet of which received one of the treatments, and the remainder separated this section from the adjacent treatment. The whole plot was divided into four blocks these being separated from each other and guarded at the extremities by systematic controls of no treatment. Within each block the twenty spray and dust treatments were randomized as under :—

5 Occasions—2nd May, 16th May, 30th May, 13th June, and an accumulative dose applied on all these days.
4 Types of application on each of the 5 occasions :
(i) 12·5 mg. indolebutyric acid per unit plot in water.
(ii) 12·5 mg. indolebutyric acid per unit plot in china clay.
(iii) Water only.
(iv) China clay only.

On successive dates of treatment the heights of the shoots above the soil were 0-8 in., 0-12 in., 1-18 in., and 2-24 in. respectively.

Method of application.—The solution was made up by first dissolving the growth substance crystals in a small volume of alcohol as described by Pearse (1939) and others. For spraying an "Abol" hand syringe was used. At the first application five litres of liquid were sufficient to wet all the shoots on the eight unit plots (four single spray plots, four accumulative spray plots) but subsequently it was necessary to dilute to ten litres, i.e. from 20 p.p.m. to 10 p.p.m. indolebutyric acid. The same quantities of liquid were applied to plots receiving water only.

The dust was impregnated as described by Stoutemyer (1939), a method in which the growth substance crystals are first dissolved in alcohol which is then used to make a paste with talc. The paste is dried to a dust in the dark and thoroughly mixed with china clay. The quantities used at each application for the eight unit plots were 100 mg. indolebutyric acid, 20 c.c. alcohol, 50 gm. talc and 950 gm. china clay. The "dust only" plots received 1,000 gm. china clay. Dust was applied by gentle shaking through a small hand sieve of $\frac{1}{30}$ inch mesh, and was sufficient to cover all the shoots and the surface of the soil immediately around their bases.

All the layers, including the untreated, were lightly earthed after each application and the usual earthings were carried out during the growing season as required by the etiolation method.

Results.—Frequent inspection of the layer bed during the summer and autumn revealed no differences in shoot growth which could be related to treatment. In December the layers were harvested and the crop was sorted according to size of shoot and amount of root into the following grades, (i) those fit to line out for budding, (ii) those fit only for bedding, and (iii) those with no roots. Records were also taken of shoots left on the layer bed for pegging down for the next year's crop. When the records were summarized no consistent differences were apparent. The data for "rootstocks fit to line out" were statistically analysed and this confirmed that the treatments had not improved the crop. Sample rooted layers were taken from untreated plots and from plots which had received growth substances in dust or liquid form at all four times of application. The roots from each layer were removed and dried to constant weight. It was found that the amount of root per layer had likewise not been affected by the growth substance treatments given.

Conclusions.—The only experiment which showed significantly better output of rootstocks due to treatment by growth substance sprays was in 1943, when a layer bed of Brompton was sprayed with one concentration on one occasion. The other experiments in that year, one on Brompton with three different spray treatments including two occasions, and the other on Myrobolan B with much higher concentrations of growth substance, showed no effect. The 1944 large-scale experiment on Myrobolan B, using indolebutyric acid, the compound which had given quite striking results on this rootstock when introduced into wounds (Sinha, 1942), failed to show any effect of growth substance when applied in the form of spray or dust, whatever the time of treatment or whatever its frequency. It is thus to be concluded that growth substances applied to layer beds in these ways, in the absence of wounding, are unlikely to confer any practical benefit.

Acknowledgements.—The writers wish to acknowledge the help of the Statistical Section of the Station in planning the experiments and for analysing the data.

Summary.—Experiments are described in which synthetic growth substances were applied to established plum rootstock layer beds in the form of sprays and dusts. In one experiment the crop of rooted shoots was increased by spraying, but in two others of similar size, and in one large-scale experiment, negative results were obtained. It is concluded that such spray treatments, in the absence of wounding, are unlikely to have any practical value.

References

Feilden, G. St. C., and Garner, R. J. (1940). "Vegetative propagation of tropical and sub-tropical plantation crops." *Tech. Commun. Imp. Bur. Hort. Plant. Crops*, **13**, 99.

Garner, R. J. (1943). "Raising rootstocks." *Rep. E. Malling Res. Sta. for 1942*, A**26**, 84-90.

——— (1944). "Propagation by cuttings and layers. Recent work and its application, with special reference to pome and stone fruits." *Tech. Commun. Imp. Bur. Hort. Plant. Crops*, **14**, pp. 79.

Knight, R. C., Amos, J., Hatton, R. G., and Witt, A. W. (1928). "The vegetative propagation of fruit-tree rootstocks." *Rep. E. Malling Res. Sta. for 1926-7* Suppl. A**10**, 11-30.

Lange, E. G. (1942). "Der Einflusse der Bodenfeuchtigkeit und Bodentemperature auf den Verlauf der Bewurzelung bei den Apfelunterlagen E.M. i-xviii." *Gartenbauwiss.* **14**, 1-76.

Pearse, H. L. (1937). "The effect of phenylacetic acid and of indolebutyric acid on the growth of tomato plants." *J. Pomol.*, **14**, 365-75.

——— (1939). "Plant hormones and their practical importance in horticulture." *Tech. Commun. Imp. Bur. Hort. Plant. Crops*, **12**, pp. 88.

Sinha, A. C. (1942). "Studies on the vegetative propagation of plum rootstocks by layering." *J. Pomol.*, **20**, 1-11.

Stoutemyer, V. T. (1939). "Talc as a carrier of substances inducing root formation in soft-wood cuttings." *Proc. Amer. Soc. hort. Sci.*, **36**, 817-22.

Thakurta, A. G., and Dutt, B. K. (1941). "Vegetative propagation of mango from gootes (marcotte) and cuttings by treatment of high concentration auxin." *Curr. Sci.*, **10**, 297.

ABNORMAL LIGNIFICATION IN THE WOOD OF SOME APPLE TREES*

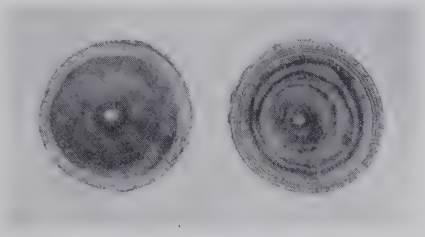
By A. BERYL BEAKBANE and ELEANOR C. THOMPSON

For some years past a condition generally referred to as "Rubbery Wood" has been observed in many Lord Lambourne apple trees. A characteristic feature of this rubbery wood is the flexibility of the affected shoots and branches, which allows them to be bent much farther than normal shoots before breaking just as if they were composed of rubbery material. The affected branches usually taper very rapidy from base to tip. The cause of the trouble has not yet been established but suggestions as to its origin have been put forward by several workers.[1 2 3]

Histological investigations carried out at East Malling Research Station have shown that the flexibility of the stems is associated with a lack of lignification of many of the xylem fibres and vessels. Lignification appeared to be normal in one-year-old lateral shoots from "rubbery" branches, except for occasional small areas near the cambium. In older shoots, and in the main stems of one-year-old

* Reprint of Letter to *Nature*, Vol. 156, p. 145, 1945.

trees, most of the summer wood was unlignified, the spring wood alone giving the usual reactions to lignin stains; but even the spring wood was found to be unlignified in some very severely affected shoots more than two years old. This lack of lignification can be seen by the naked eye when a cross section of the wood from a living branch is suitably stained, e.g. with a 0·5 per cent. solution of phloroglucinol in concentrated hydrochloric acid. The pale unstained areas of unlignified tissue

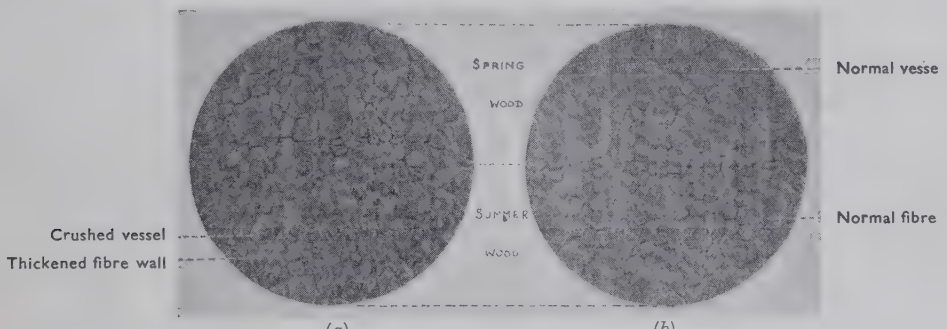


(*a*) (*b*)

FIG. 1. Miller's Seedling. Transverse sections of (*a*) normal branch; (*b*) "rubbery" branch. Nat. size.

contrast with the red-stained normal wood. (Fig. 1.) The phloem and pericycle fibres were normally lignified in all the affected specimens. (Fig. 1.)

In the unlignified areas the walls of the vessels and fibres gave the usual staining reactions of cellulose. The vessels had irregularly shaped walls and some had collapsed altogether (Fig. 2.). The xylem fibres were more or less circular in transverse section, with abnormally thick walls surrounding a very small central cavity. In general appearance they resembled the description of the gelatinous fibres of tension wood.[4] Their distribution within the stem was, however, different since the bands of gelatinous fibres in tension wood have seldom been observed to pass round the whole stem, whereas in "rubbery" wood they often did so.



(*a*) (*b*)

FIG. 2. Lord Lambourne. Structure of (*a*) "rubbery" wood; (*b*) normal wood. x 180.

A similar lack of lignification has recently been observed in "rubbery" branches from trees of the apple varieties, Miller's Seedling, Dartmouth Crab and James Grieve. The affected plants of the first two varieties were growing near trees of Lord Lambourne known to be "rubbery".

In conclusion, we should like to thank Dr. T. Swarbrick (Long Ashton Research Station), Mr. G. M. Stuart (East of Scotland Agricultural College), Messrs. Chandler & Dunn (Canterbury), and Mr. R. Taylor (Barming, Kent), who kindly provided some of the specimens.

Summary.—The condition known as "Rubbery Wood", particularly associated with Lord Lambourne apple, is shown to be associated with a lack of lignification in many of the xylem fibres and vessels.

REFERENCES.

1 WALLACE, T., SWARBRICK, T., and OGILVIE, L. *The Grower* **22** (49), 12 (1944).
2 CRANE, M. B. *The Grower*, **22** (53), 10 (1944).
3 ——— *Nature*, **155**, 115 (1945).
4 RENDLE, B. J. *Tropical Woods*, **52**, 11 (1937).

OUTDOOR TOMATO TRIALS, 1944

By HILARY M. HUGHES

OUTDOOR tomato trials were again carried out in the walled garden at Bradbourne, during 1944. These form part of a series of trials initiated in 1940 at the Glasshouse Demonstration Station, Wilmington, Kent. An account of the trials in 1943 has been published (Corbett and Hughes, 1944) and a paper now in the press (Corbett, 1945) gives a more detailed account of the whole series. The results of the duplicate variety trial in 1944 at Wilmington are included in this paper by courtesy of Mr. Corbett and the Kent Education Committee, for comparison with those at Bradbourne.

The 1944 trials consisted of I, a Variety Trial and II, a trial to compare different methods of raising plants for outdoor planting. Both trials were duplicated at Wilmington, where all the plants were raised. The initial preparation of the ground and the method of supporting plants was similar to the 1943 trial (Corbett and Hughes, 1944). Plants from 3 in. pots were trowel-planted on 1st-5th June, 18 in. apart in rows 3 ft. apart. The soil was exceptionally dry, only 4·35 in. rain falling in the first five months of the year compared with the average for Malling of 9·71 in. The oscillating overhead irrigation system was used three times to supply the equivalent of 2 in. of rain over a three weekly period after planting. The advantage of irrigation in the warm dry garden was seen by the difference in growth between those irrigated and a few plants outside the trial that were not watered. Standard varieties were deshooted and trained in the usual way, and all the plants dusted with a copper lime dust at fortnightly intervals from the beginning of August. All plants were stopped at one leaf above the last truss with set fruit on 5th August. A proportion of the plants in all the trials was attacked by the Black Dot foot rot identified* as *Colletotrichum atramentarium*, but this occurred late in the season and did not seriously impair cropping. Individual plants were attacked by blight at the end of September, but this affected the storage of the green fruit only. All green fruits that were sound were cleared off on 28th September and ripened in the packing shed during October-November.

Trial I.—Variety Trials.—This trial included four standard varieties, Market King, Carrick, Ailsa Craig and Earliest of All, compared with five of the " bush " varieties, First in the Field, Stambovoi, Victor, Fargo's Self Pruning, and Dwarf Gem (Stoner's) in four randomized blocks of nine plots. The bush varieties had aroused considerable interest amongst amateurs and commercial growers in 1943 and somewhat extravagant claims had been made for them. First in the Field and Stambovoi appeared identical in appearance and habit of growth. The leaves were dark green and very crinkled and the distance between the trusses about half the length usual in standard varieties ; in both varieties only 3-4 stems were retained carrying about 8 trusses in all when stopped. It was necessary to support these with a loop of string around the stems. Fargo and Dwarf Gem were similar in habit, each plant throwing numerous side shoots with small leaves that terminated in a truss and continued growth by further laterals. Both varieties formed many more flower trusses than could be carried by the plant, and it was necessary to thin out the shoots drastically, and to support those remaining with a loop of string. The variety Victor was similar to Dwarf Gem and Fargo in growth, but carried exceptionally large fruit on the first two trusses and made considerably fewer laterals ; less thinning was required but it was difficult to prevent the fruits from touching the ground. Some of the fruits of the last three varieties in spite of support were on the ground and were attacked by millipedes and wireworms, and various parasitic and saprophytic fungi. Stambovoi and First in the Field carried the fruit clear of the ground, if trained, but trailed along the ground if not supported. It appeared that the amount of labour required for the bush types, if thinned, stopped and supported, was not much less than that required for growing standard varieties. However, methods of growing these varieties unsupported along straw or low parallel wires, if successful, would take less labour than standard varieties.

Results.—Picking from most varieties commenced 8th-12th August. Carrick was noticeably latest in ripening. The crop summary for Bradbourne, Table I, can conveniently be compared with that for an identical trial at Wilmington shown in Table II. The tables should be studied with caution as the " ripe fruit " included all split and blotchy second grade saleable fruit as well as first grade fruit. It was not possible to keep these separate, but approximately 40 per cent. at the beginning and 60 per cent. at the end of the season was second grade. The heavy crop from Victor was due to the first fruits, which were exceptionally large, uneven and furrowed, and the variety cannot be recommended for retail sale, although possibly of interest for manufacturing purposes where weight

* Identified by Dr. Ware and Mr. Glasscock of Wye, Kent.

is the main consideration. The fruit of Dwarf Gem was even in size but rather small, owing to the many fruits set. The early ripening of Earliest of All was unfortunately not maintained and this variety again showed symptoms, as in 1943, of Blossom End Rot which wasted a considerable quantity of the second early fruit. There is no doubt, however, that it is one of the earliest varieties to ripen and is generally of a good shape and colour. There was little difference between Stambovoi and First in the Field. The fruit was a light bright red and the veining rather pronounced; the flavour was good, but the fruits rather small, 10-12 to the pound. Fargo had a large number of small fruits at the end of the season, but the earlier fruits were a reasonable shape and size. Ailsa Craig gave a firm beautifully coloured sample and ripened off well in store, but the green fruit was liable to crack.

TABLE I.

OUTDOOR TOMATO VARIETY TRIAL. BRADBOURNE, 1944.

Crop Summary.

Variety.	No. of plants out of 384	Ripe Fruit.					Green Fruit.		Total Crop.	
		Average Crop in lb. per plant.				Tons per acre.	lb. per plant.	Tons per acre.	lb. per plant.	Tons per acre.
		Aug.	Sept.	Oct.	Total.					
Victor (B)	374	1·06	1·77	0·58	3·41	14·7	0·89	3·9	4·30	18·6
Dwarf Gem (B)	367	0·99	1·71	0·37	3·07	13·3	0·52	2·2	3·59	15·5
Ailsa Craig	353	0·73	1·52	0·75	3·00	13·0	1·75	7·5	4·75	20·5
Fargo (B)	380	0·65	1·69	0·46	2·80	12·1	0·59	2·5	3·39	14·6
Earliest of All	333	1·21	1·22	0·31	2·74	11·8	0·55	2·4	3·29	14·2
Stambovoi (B)	364	0·73	1·33	0·55	2·61	11·3	0·97	4·2	3·58	15·5
Carrick	352	0·44	1·60	0·48	2·52	10·9	1·05	4·5	3·57	15·4
First in the Field (B)	380	0·71	1·15	0·47	2·33	10·1	1·34	5·8	3·67	15·9
Market King	345	0·70	1·10	0·51	2·31	10·0	1·59	6·9	3·90	16·8
Sig. Diff. P=0·05	—	0·15	0·27	0·14	0·43	—	0·32	—	0·54	—

Note.—Figures are based on a 18 in. by 3 ft. plant giving 9,680 plants per acre.

Market King did not crop well, and both ripe and green fruit split badly; it appears that our conditions are not suitable for this variety. It also showed more blotchy ripening than the other varieties. This trouble which causes uneven colouring of the fruit is associated with low available potash and/or low sunshine, it can usually be corrected by generous potassic manuring in peace time and adequate crop rotation (Bewley, 1941). The fact that tomatoes were grown on the same soil in 1943, coupled with the low sunshine in September, 1944, may have been the cause of the high

TABLE II.

OUTDOOR TOMATO VARIETY TRIAL. WILMINGTON, 1944.

Crop Summary.

	Ripe Fruit.					Green Fruit.		Total Crop.	
	Average Crop per plant.				Tons. per acre.	lb. per plant.	Tons per acre.	lb. per plant.	Tons per acre.
	Aug.	Sept.	Oct.	Total.					
Earliest of All	0·62	0·83	0·18	1·63	7·0	0·97	4·2	2·60	11·2
Dwarf Gem (B)	0·33	1·01	0·24	1·58	6·8	2·10	9·1	3·68	15·9
Ailsa Craig	0·31	0·88	0·29	1·48	6·4	1·65	7·1	3·13	13·5
Victor (B)	0·22	1·01	0·23	1·46	6·3	1·95	8·4	3·41	14·7
Stambovoi (B)	0·47	0·63	0·25	1·35	5·8	1·51	6·5	2·86	12·4
Fargo (B)	0·23	0·91	0·20	1·34	5·8	1·87	8·1	3·21	13·9
First in the Field (B)	0·45	0·62	0·23	1·30	5·6	1·49	6·4	2·79	12·1
Carrick	0·22	0·89	0·14	1·25	5·4	1·10	4·8	2·35	10·2
Market King	0·28	0·73	0·20	1·21	5·2	1·42	6·1	2·63	11·4
Sig. Diff. P.=·05	0·08	0·21	—	—	—	0·49	—	0·69	—

proportion noted. The fruit splitting of all varieties was possibly enhanced by the heavy rainfall in August of 3·66 in. compared with the average of 2·22 in. Dwarf Gem was not so liable to splitting as the other varieties grown.

Discussion.—It must be emphasized that seasonal conditions have a very great influence on the yield of outdoor tomatoes, a crop that is possibly more dependent on the incidence and distribution of rain and the amount of sunshine than most others.

Although it would be unwise to praise or condemn the newly introduced bush varieties of tomato for outdoor cultivation on one, and climatically unfavourable, season's trial, it appears that Victor is not a suitable variety and Dwarf Gem and Fargo are only suitable if simple methods to keep the fruit off the ground can be devised. First in the Field and Stambovoi crop well if supported in the usual manner and are worthy of further trial. None of the bush types was markedly superior to the best standard varieties.

Trial II.—Pot compared with Tray Raised Plants.—Two varieties Harbinger and Market King were included and half the plants of each variety raised by potting off into 3 in. pots, the other half by pricking out into standard seed trays to hold 2 dozen plants. The plants, raised at Wilmington, were grown under similar conditions. The trial was planned as 6 blocks of 4 plots with 3 rows of 16 plants per plot. Cultural conditions were similar to those of Trial I.

TABLE III.

POTS AND TRAYS. BRADBOURNE, 1944.

Crop Summary.

	Ripe Fruit.					Green Fruit.		Total Crop.	
	lb. per plant.				Tons per acre.	lb. per plant.	Tons per acre.	lb. per plant.	Tons per acre.
	Aug.	Sept.	Oct.	Total.					
Harbinger Pots	0·67	1·14	0·36	2·17	9·4	1·94	8·4	4·11	17·8
Harbinger Trays	0·10	1·08	0·52	1·70	7·3	1·49	6·4	3·19	13·7
Market King Pots	0·62	1·47	0·53	2·62	11·3	1·58	6·8	4·20	18·1
Market King Trays	0·05	0·80	0·30	1·15	5·0	1·08	4·7	2·23	9·7
Market King *v.* Harbinger	—	—	—	—	—	×	—	—	—
Pots *v.* Trays—Harbinger	× × ×	—	×	× ×	—	×	—	×	—
Pots *v.* Trays—Market King	× × ×	× × ×	× × ×	× × ×	—	×	—	× × ×	—

Note.—Tonnage based on 9,680 plants per acre at 18″ × 3′.

× significant P < ·05.
× × very significant P < ·01.
× × × very highly significant P < ·001.

Results.—Table III gives the crop summary for the Bradbourne Trial; an identical trial carried out at Wilmington is not included as there were no significant differences between treatments. This may have been due to low yields from all plots. In the Bradbourne Trial a comparison of the two varieties and their differential response to the two methods of plant-raising is interesting. It is clear that pot raised plants gave earlier and heavier yields of ripe fruit than those from trays, but that this was more marked in Market King (i.e. tray raised Harbinger plants do not compare so unfavourably with pot raised Harbinger plants). It is interesting that there were no significant differences between varieties, yet, in 1943, Harbinger cropped significantly heavier than Market King at Bradbourne. The total crop per plant shows that pot raised plants gave higher total yields as well as earlier crops.

Discussion.—Under East Malling conditions in 1944, pot raised plants gave significantly more satisfactory crops than tray raised plants. It is possible that in certain varieties this difference is less marked. The slightly increased cost of purchasing and planting pot plants would be returned by increased yields, but in view of the effect of seasonal conditions on tomato growth and cropping, trials like this should be carried out over a period of a few years to give an adequate basis for unqualified recommendations.

Acknowledgements.—Thanks are due to Mr. W. Corbett, K.W.A.E.C. Advisory Officer who provided the plants and suggested the trials; to the Kent Education Committee for permission to

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1944.

Month.	Temperature in Screen.					No. of Ground Frosts	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	30 years' average.	Total Hours.	Average per day.	30 years' average.	4 inches.	8 inches.	2 feet.
January	49	37	56	24	43	8	1·50	0·36	2·53	40·5	1·3	45·8	40·3	42·0	41·6
February	42	33	56	23	37	17	1·25	0·67	1·82	63·9	2·2	67·3	36·8	39·7	40·9
March ..	52	31	68	25	41	26	0·06	0·02	1·52	101·6	3·2	118·7	37·9	—	40·1
April ..	60	40	72	29	50	10	1·06	0·31	1·96	153·3	5·1	131·7	49·1	—	48·7
May ..	64	40	87	24	52	10	0·48	0·30	1·73	233·9	7·5	198·3	54·5	53·6	54·4
June ..	67	48	74	37	57	0	1·26	0·42	1·41	178·2	5·9	204·0	59·9	59·5	60·4
July ..	70	54	78	49	62	0	2·22	0·92	2·17	133·0	4·3	190·7	67·7	62·2	63·2
August ..	74	55	86	44	64	0	3·66	1·85	2·20	208·8	6·7	181·9	65·9	65·0	67·8
September	63	50	73	37	56	2	2·53	0·52	2·06	138·4	4·6	145·8	55·9	56·0	59·3
October	55	42	60	30	48	4	5·30	1·01	2·72	79·6	2·6	100·9	48·4	49·0	53·1
November	50	37	59	23	43	17	4·21	0·70	2·96	57·1	1·9	53·7	42·1	42·7	45·2
December	44	33	55	22	38	17	1·87	0·75	2·49	52·1	1·7	39·1	37·2	38·3	41·7
Totals						111	25·40		25·57	1440·14		1477·9			

(See p. 43.

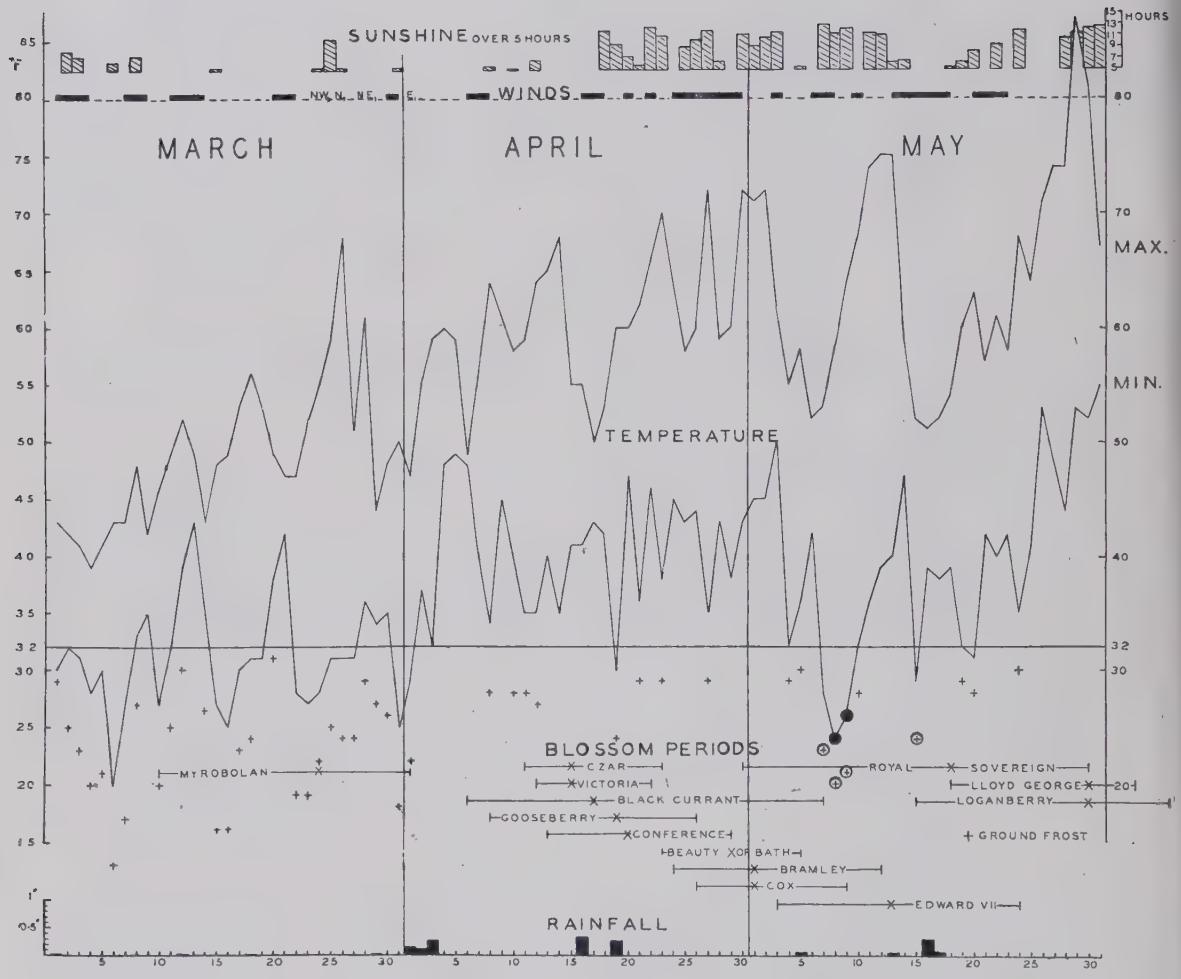


Diagram to show the weather recorded during the Blossoming Season, 1944.

blish results of the trial at Wilmington ; and to members of the Statistical Section for help with e statistical interpretation of results.

Summary.—A trial of outdoor tomatoes under 1944 conditions showed that bush types of tomato led some form of training and support. Crop records show they compare favourably with standard rieties. Notes are given of the habit of growth and kind of fruit of the bush types. Another al suggested that pot raised plants gave heavier and earlier yields than tray raised plants. A ge amount of splitting and blotchy ripening in both trials was noted, and reference made to the usual distribution of rainfall.

References

ORBETT, W. (1945). "Experiments on the Production of Tomatoes in the Open." *J. Pomol.*, **22.** In the Press.

——, and HUGHES, H. M. (1944). "Outdoor Tomato Variety Trial, 1943." *Rep. E. Malling Res. Sta. for 1943*, 44-7.

EWLEY, W. F. (1941). "Tomatoes." *Ministry of Agriculture Bull.*, **77**, p. 52.

WEATHER CONDITIONS DURING 1944

By H. M. TYDEMAN and A. P. PRESTON

HE weather conditions during 1944 were very unsatisfactory from the point of view of both the uitgrower and the arable farmer. A series of ground frosts which occurred intermittently throughout e blossoming period of plums, apples and pears and which culminated in several frosts of exceptional verity shortly after the fruiting period of most fruit varieties was over, destroyed the prospects of promising crop.

For the arable farmer, the very dry conditions which prevailed throughout the earlier part of e year adversely affected the growth of young corn and potatoes, particularly on the lighter lands. n the Station's arable farm and in the experimental nurseries and in the hop gardens the effects were verely felt. (See Farm Report, p. 13.)

Apart from the exceptional prevalence of ground frosts throughout the earlier half of the year, mperatures did not vary greatly from the average. While the total rainfall for the year of 25·4 ches was less than two-tenths of an inch below the 30 years' average annual rainfall here, its stribution was somewhat remarkable. Up till the end of June only slightly more than one-fifth the year's total rain had fallen. Throughout the latter half of the year some extremely heavy onthly totals were recorded, and only in December was the rainfall below normal. (See p. 41.)

The year's sunshine totalled 1,440 hours, rather less than 40 hours below the 30 years' average. pril, May, August and December had a considerable excess, while June and July with a deficiency over 80 hours between them were the most notably deficient.

The writers are indebted to Mr. T. N. Hoblyn and the Staff of the Statistical Section for their ssistance throughout the year and for the preparation of the accompanying diagram.

BIOCHEMISTRY

MINERAL DEFICIENCIES IN AGRICULTURAL AND HORTICULTURAL CROPS*

By W. A. ROACH

Introduction.—Earlier Reports (Roach, 1939 ; Thompson, 1939 ; Roach, 1944) have described ow plant analysis and plant injection methods have been used to diagnose mineral deficiencies in uit trees and other plants both in this country and overseas. The present communication describes riefly how these methods have been developed and applied to agricultural, as well as horticultural rops for increasing food production during the war years, 1942-44. More detailed descriptions of the arious lines of work will be published in due course by the workers concerned. The work was under-aken as a result of a memorandum submitted by Professor V. H. Blackman and Dr. R. G. Hatton

* Report of work done by the joint team of the East Malling Research Station and the Research Institute of lant Physiology, Imperial College of Science and Technology. 1942-1944.

to the Agricultural Improvement Council and it was financed by the Agricultural Research Council. An *ad hoc* committee co-ordinated the work of this team with that in progress at various other Institutes.

Members of the Research Institute of Plant Physiology, Imperial College of Science and Technology, co-operated with the Biochemistry Section of the East Malling Research Station and this joint team was augmented by appointments made by the Agricultural Research Council.

The Research Institute of Plant Physiology members of the team concerned themselves mainly with the physiological aspects of the work.

The value of any diagnostic method, or combination of methods, must be judged by the extent to which it reveals correctly the nature of deficiencies and predicts the degree of seriousness of their effects on yield and quality of crop ; and its value will be enhanced if diagnosis can be made early enough for remedial measures to be applied to the current season's crop.

Some idea of the effects of deficiencies on crop yield may be obtained by comparing the yields of " deficient " crops with those growing under similar conditions but not affected by the deficiencies in question. The effects may also be measured by comparing untreated crops with corresponding crops in which the deficiencies have been made good. The results of spraying or injection experiments will tend to give low figures because of the difficulty of determining the optimal amount and conditions for making good the deficiencies completely. The same is true of experimental applications to the soil, but the interpretation of the results of such experiments is complicated by the fact that ionic exchange between the substance applied and the soil particles results often in the enrichment of the plant by other elements in addition to the one applied to the soil. Plant analysis reveals some of these complications.

The cure of mineral deficiencies has therefore been worked on both as an end in itself and as a means of measuring their effect in depressing crop yields.

Methods.—The work was based mainly on three methods :

1. **Analysis of the plant** revealed what it had absorbed from the soil, and the comparison of the results obtained on unhealthy with those on healthy plants frequently suggested the causes of poor cropping.

2. **By leaf injection** selected nutrients were introduced each into a part of a leaf, and their effects were observed a week or so later by comparison of the permeated with a corresponding untreated part of the same leaf.

3. The indications of the first two methods were followed up by **curative experiments** under practical conditions in the field. The difficulties involved in carrying out experiments on crops remote from headquarters and not completely under the control of the experimenter were realized at the outset. But these were faced because it is important that the conditions of the experiments should approximate as closely as possible to those of the crops to which the findings are to be applied. How far this line of action was justified may be judged from the results submitted later.

The aim of these curative experiments was both to measure the effect of the deficiencies on crop yield or quality, and to test how far they can be made good by commercially applicable remedial measures.

Plant Analysis. Choice of Sample for Analysis.—The leaf was selected for analysis for diagnostic purposes because in it the minerals take part in the synthesis of the raw materials out of which the bulk of the plant is built up. As the leaves grow they alter in mineral composition. It is important, therefore, to gather them when at a definite stage of development. Moreover they tend to be contaminated with dust from soil, and, in places, from railway smoke or quarry dusts. Consequently the standard sample consisted of leaves that had just become fully expanded. This is a definite and easily recognizable stage of growth. Contamination is usually not serious and the leaf has attained maximum strength and can be cleaned by rubbing with clean muslin.

Goodall (1943, 1945 (*a*) and (*b*)) working on the apple, has shown that there are greater differences in mineral composition between leaves from healthy and unhealthy trees when these are gathered from the base of the extension shoot, and more so from non-fruiting spurs, than when they are gathered from near the top of the extension shoot as in the standard method ; but there are too few data on which to decide which type of leaf gives the most reliable diagnosis judged in terms of increase in yield as a result of treatment.

Analytical Methods.—At first limitations of staff allowed of only one method of analysis being applied. This was a flame method of spectrography worked out in this laboratory.

Flame spectrochemical Method.—A description of this is ready for publication (Roach, 1945). It has been in routine use for the elements potassium, calcium, magnesium, manganese.

Deficiencies of potassium, calcium and manganese have been diagnosed in many samples and confirmed by other methods. Magnesium deficiency has also been indicated in a number of samples but confirmatory evidence is not so complete as for the other deficiencies. Excesses have also been

agnosed, the commonest of which is that of calcium, which tends to interfere with the proper uptake d utilization of the trace elements—a condition known as "*lime-induced chlorosis*". Iron is the ement most commonly influenced. Its uptake may be so lessened as to lead to true iron deficiencies, be mentioned later, but more often excess calcium is accompanied by abnormally high iron in a rm useless to the plant, as is shown by the improvement resulting from injecting iron in a suitable rm such as ferrous sulphate. When, therefore, calcium is present in excess injection has been nsidered essential for a complete diagnosis.

A *quantitative* modification of this flame method of spectrography has been evolved by Drs. Bolas d Goodall who are preparing a description of it for publication. It has been used mainly for the hysiological aspects of the work.

The Lundegardh Method.—The apparatus arrived recently and is nearly ready for use and it will possible to test the range of usefulness of the two methods. That of the Lundegardh is somewhat mited by the comparatively large samples needed. These are not always available and when they e, the cleaning and preparation are time consuming.

Polarographic Method.—A great advantage of spectrochemical methods of analysis is that a umber of elements are estimated at the same time on the same sample, with consequent saving of me and material; and a fairly general "picture" of the mineral content of the plant is obtained y mere inspection of the spectrogram. Work begun some fifteen years previously in this laboratory, h the polarograph, was restarted in the hope of adding a second method that would estimate a umber of elements simultaneously using a portion of the same small sample, since there appeared be good reason for hoping that a combination of the two would cover nearly all the elements of iological interest with some degree of desirable overlap and the efficiency of the two methods is optimal different ranges in the electrochemical series of elements.

The method has been used for the routine detection of excesses of zinc and other trace elements, ut further work may be necessary before it can be used for the detection of deficiencies, and samples f at least 5 grams may be necessary.

In normal and deficient leaves the amounts of the trace elements are so small that it is difficult y ordinary methods of ashing to attain a concentration which may be estimated precisely, even by he most sensitive known methods of analysis. Future work will therefore be directed to isolating he trace elements so that polarograms may be made on small aliquots of solutions in which they have een concentrated. This course entails a considerable loss in rapidity but this seems unavoidable.

Theoretical considerations have suggested a modification of the construction of the dropping ube which increases the sensitivity of the method.

Colorimetric Method for Iron.—Iron was estimated by a modification of R. Hill's method for stimating iron in biological material. This has been in routine use for some months and has led to he discovery of examples of true iron deficiency which appear to be of considerable economic import-nce. These will be mentioned later. They are distinct from most of the earlier examples of iron deficiency" in which the plants contained abnormally large amounts of iron in a form useless to he plant. The diagnosis of true iron deficiency by the flame method of spectrography now in routine se is difficult, because the faint iron lines are made indistinct by a "cloud" due to magnesium. This quantitative method for iron is therefore a valuable addition.

Colorimetric Methods for Boron.—Boron was determined by a quantitative modification of the quinalizarin method of Berger and Truog worked out by J. P. R. Riches in this laboratory.

Phosphorus.—A Spekker absorptiometer was used to determine phosphorus by a molybdenum blue method, reduction being effected by hydroquinone and sodium sulphite.

General Remarks on Analytical Methods.—The analytical work has been developed to satisfy the mmediate practical needs of the field work. For this a quick qualitative diagnosis on a small sample was often preferable to a slower and more exact analysis. Many extensions and refinements in analy-ical method, known to be desirable from the first, were postponed in favour of applying those methods already yielding results of practical value to a wider range of plant material. The most urgent develop-ments for the future would appear to be routine analytical methods for nitrogen, sulphur, copper and zinc and, hardly less urgent, for nickel, cobalt and molybdenum. It would be a great advantage if these routine methods could at the same time be applied to such elements as silicon, titanium, vanadium and chromium which commonly occur in plants. Arc and spark methods with the large spectrograph should satisfy most of these requirements, but the same considerations apply as to those mentioned above for the polarograph, and concentration is necessary for some of these elements.

Plant Injection.—The diagnostic plant injection methods available at the beginning of this work were those described by Roach (1938, 1939) with improvements described by Roach and Roberts 1945).

During 1944 a simple and effective method was evolved for cereals. Results obtained with t will be mentioned later. A note describing it is being prepared for publication.

Threshing Ear Samples.—For the field work some thousands of samples consisting of about a double handful of ears had to be threshed for estimating yield. A small thresher suitable for this purpose was constructed which threshes and winnows away the chaff in one operation, leaving the grain in a drawer ready for weighing.

Field Work.—Field work was carried out mainly in the following localities:

Devon.—1. Derelict lands on the Culm Measures and Clay-with-Flints areas, where deficiencies of calcium and magnesium and indications of others were found, in addition to that of phosphorus already known, that of calcium being proved of major economic importance.

2. Red Soils, on which evidence of deficiencies of phosphorus, potassium and calcium, and indications of trace element deficiencies was obtained.

3. Various localities on potatoes, in which the main deficiency was found to be potassium, deficiencies of phosphorus and trace elements also being indicated (in co-operation with Mr. E. C. Large of Seale Hayne Agricultural College and Messrs. Patterson and Le Riche of Dartington Hall Estates).

4. Various localities on field beans in which deficiencies of potassium and phosphorus were found (in co-operation with Mr. E. C. Large and Messrs. Patterson and Le Riche).

Kent.—1. The Marshlands of South Kent, where a deficiency of manganese was proved to be both widespread and economically serious, and where indications of other deficiencies (iron, zinc, boron, copper and nickel) were obtained.

2. The lake bed at Bradbourne, East Malling, where comparative work was done on a variety of plants, growing in a calcium carbonate impregnated peat, the majority of the plants being deficient in manganese.

3. Plot 2 at the East Malling Research Station where symptoms had been diagnosed as those of magnesium deficiency.

The work done at each of these localities will now be described briefly, except the last where results have been inconclusive.

Devon.—1. Derelict Lands. 1942.—This work was undertaken at the request of and in co-operation with the Derelict Lands Sub-Committee of the Devon W.A.C. They had ploughed up well over 10,000 acres of *molinia* and heather moors on the Culm measures and clay with flints and had obtained satisfactory crops of oats; but potato crops had varied from medium to complete failure.

Symptoms.—Oats exhibited what were thought at the time to be symptoms of phosphorus deficiency. The potato plants were everywhere stunted. In places a few plants exhibited slight leaf roll. Leaf roll virus was known to be present. No diagnosis of mineral deficiency could therefore be made on the basis of symptoms.

Leaf analysis of samples of good and poor crops of potatoes from seven localities showed all the poor samples to be deficient in calcium. The D.W.A.C. Officers were unwilling to accept this diagnosis of calcium deficiency as an important cause of the crop failure in face of the deep rooted belief that " potatoes do not need *lime* ".

Leaf injection.—A strong response was given to calcium at all five localities at which leaf injections were done.

Yield Sampling carried out in late summer at various places where neighbouring areas of potatoes had been found by leaf analysis to be relatively high and low respectively in calcium gave a completely satisfactory correlation between yield and calcium content. The relatively high calcium contents were due, in the various localities to :

(*a*) Differences in artificial manuring. The mixture made up by the D.W.A.C. contained calcium added in the form of triple superphosphate and in the form of limestone dust added (at the rate of 1½ cwt. per acre) to make the manure flow freely through the drill.

(*b*) Animal faeces dropped relatively abundantly where animals tended to congregate, e.g. in sheltered spots.

(*c*) An " unofficial " application of limestone dust to part of one field. This was proved to have increased the yield from ½ ton per acre to 6 tons per acre, ware and seed. (See Fig. 1.)

The D.W.A.C. officials, who were impressed by the leaf injection results, were fully convinced by the yield data and asked for advice even before this data was complete. The advice was to apply a calcareous dressing to the whole area, except the relatively small acreages near limestone outcrops, where yields had already been satisfactory. Since plant analysis and plant injection (but not symptoms) gave, in addition to calcium deficiency, in certain localities indications of magnesium deficiency, it was recommended that magnesian limestone dust, or other calcareous rock containing high amounts of magnesium should be used as far as possible, but that when this was not possible a limestone containing little magnesium should be applied. And, in view of the number of indications of a tendency towards trace element deficiencies, it was suggested that the limestone dressings be looked upon as

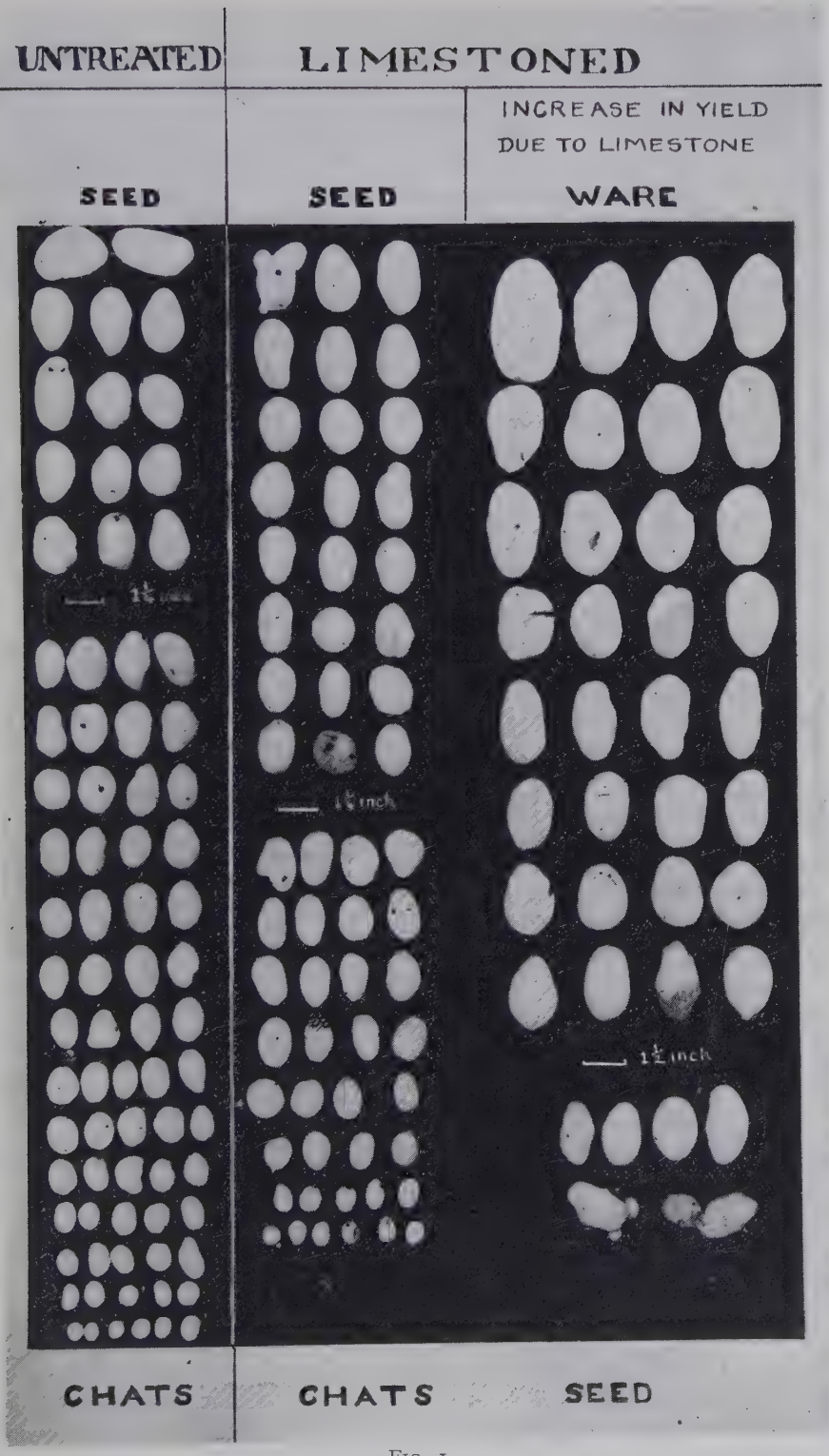


FIG. 1.

Yield and size of potatoes from untreated and limestoned areas of moorland. There were no tubers of ware size on the untreated area. The yield of chats was reduced by the treatment. There was a slight increase in the tubers of seed size, but the main part of the large increase in crop was in the tubers of ware size.

the application of an artificial manure (say at the rate of 2 or 3 cwts. per acre) to supply calcium rather than as liming to any particular *p*H.

The D.W.A.C. immediately had a survey made of the calcium resources of the County and during the winter a dressing was applied to the whole of the huge area needing it.

The Effect of the Treatment. 1943.—Whereas in 1942 potato crops failed completely on some hundreds of acres, the minimum crop in 1943 was 6 tons per acre and crops of 10 tons per acre were common. Mr. F. R. Horne of the Devon W.A.C. estimated that an additional 3,000 tons of potatoes resulted from the calcareous dressing applied to the derelict lands of Devon, i.e. $\frac{1}{80}$ the increase in potato crop for the whole country.

It is fully realized that this result could not have been achieved without the wholehearted co-operation of Mr. F. R. Horne, Captain R. Wellington and Mr. G. H. Murrin in determining the cause of the crop failure and without the extraordinary energy displayed by these and other D.W.A.C. Officers in applying the remedy to such a large area in such a short time.

Some assessment may here be attempted of the value of plant analysis and injection in this particular instance. Up to this time there had been no clear practical demonstration of calcium deficiency in potatoes grown on acid peats to counter the dictum that " potatoes do not need lime ", which expresses the results of practical experience obtained in growing potatoes on more fertile soils. In the circumstances those with the responsibility for some thousands of acres of potatoes might well require clear demonstration of the reliability of any advice before acting on it. Visual symptoms gave no help in diagnosing the cause of the crop failure. Within a fortnight of first visiting the crops it was shown that all poor crops responded to injections of calcium chloride, that all healthy looking plants proved to be richer in calcium than corresponding unhealthy ones ; and in late summer it was proved that the yield ran parallel with calcium content. These results convinced those responsible for the crops and it may be claimed that no other known methods would in the circumstances have given such clear-cut evidence in so short a time.

Field experiments carried out on potatoes grown on freshly ploughed up moorland confirmed the importance of the effect on yield of making good both the phosphorus deficiency (already known before this work started (Horne, 1943)), and the calcium deficiency proved by this work. The fact that magnesian limestone gave a better yield than a purer limestone suggested that magnesium deficiency was also of at least secondary importance in the areas where this deficiency had been diagnosed.

1944.—The potato crops on the derelict lands in 1944 made excellent growth and during a visit in the summer Mr. Murrin was unable to show a poor looking crop. A leaf sample, gathered from the only crop that he was able to show making growth at all short of the ideal, proved on analysis to be low in phosphorus. The yields were excellent.

Calcium deficient oats and potatoes.—Mr. Murrin showed members of the team one of the few remaining small areas from which limestone dust was accidentally omitted. It was sown to oats, which were practically a complete failure where the limestone was omitted, in marked contrast with the good crop on the whole area receiving limestone. (Fig. 2.)

Amongst the oats were a number of self-set potato plants, around most of which the oats were too poor to have had any appreciable adverse effect on the growth of the potatoes. These potato plants were, at first sight, identical in appearance with those examined originally in 1942. They differed, however, in being quite free from any leaf roll symptoms. The plants, like those in 1942, were stunted, but exhibited no specific symptom in spite of the calcium deficiency being sufficiently severe to reduce the crop to practically nothing, as had happened near-by in 1942.

Importance of Mineral Nutrition in Reseeding Pastures.—The effect of application of limestone to derelict pastures is exhibited in a spectacular manner along the verges of hundreds of miles of roads through the Culm Measure areas of Devon. Limestone chippings are used for covering the roads after tarring and these are scattered by wheeled traffic on to a strip a foot or so wide on either side of the road. These strips and the sites of chipping dumps carry a good growth of wild white clover in marked contrast with the herbage not reached by the flying chippings, which is destitute of wild white clover. This observation is similar to that already recorded by Stapledon (1935) concerning other areas.

At the writer's request, Mr. Murrin looked out for any areas in which limestone dust had accidentally been omitted from reseeding pastures and very kindly took him to one near Blackmoor Gate on the edge of Exmoor. Here limestone dust had been omitted from about an acre in the corner of a field. The main part of the field, which had received the limestone dust, carried an excellent pasture on which a large number of sheep and cattle were doing well, whereas the part from which the limestone dust was omitted had reverted nearly to its original condition of rough moorland pasture. The area was reseeded in 1941. The stock had grazed the main area evenly, but had left the unlimestoned area comparatively long. They had eaten rushes quite close to the ground on the limestoned area, but had left them about 6 inches long on the unlimestoned. So clear-cut was this selective

razing that the curved edge of each area covered by a shovelful of limestone dust when distributed ood out clear cut.

What happens with one essential element may well happen with another, and the above facts ggest the supreme importance of ensuring, as far as possible, adequate nutrition to the seeds crop efore sowing it, and watching for any signs of deteriorating mineral supply during growth. Routine nalyses and possibly injection of fenced off plants might be worth doing to get early warning of the

FIG. 2.
Oats from equal lengths of drill from limestoned area (left) and untreated area (right) of moorland.

development of mineral deficiency, especially on areas which it is desired not to reseed for a long period, and particularly if the pasture is to be submitted to the strain of milk production.

2. The Red Soils of Devon, 1944.—Mr. F. R. Horne, when Chief Technical Development Officer, asked the team to determine why the cereal, notably wheat, crops on the red soils have remained more or less stationary in yield during the last decade or so, whereas that of the country as a whole has risen considerably. The red soils have had the reputation of being some of the most fertile in the country, consequently the yields of cereals are particularly disappointing.

Miss H. M. Holmes was stationed in the district to investigate this problem. Unfortunately the

diagnostic injection method for cereals was not evolved in time for her to use it for this purpose. Her work, therefore, was confined to the collection of samples for analysis from representative areas, and the observation of visual symptoms.

Visual Symptoms.—Practically no visual leaf symptoms were observed.

Leaf Analysis.—Until more data are accumulated, from which it may be possible to decide on what is the minimum content of each element compatible with optimum cropping, the safest procedure in an investigation such as this would seem to be the comparison of samples from neighbouring areas of the same crop of differing degrees of health. Such comparisons indicate definite deficiencies in 10 out of the 12 sites examined. In the remaining two the phosphorus is lower than in any high yielding crop yet analysed. The results obtained may be summarized as follows :

Total number of sites examined	..	..	..	..	..	..	..	12
Phosphorus deficiency diagnosed in	4	sites and suspected on			4	Total	..	8
Potassium	,,	,,	3	,,	,,	,,	1	,, .. 4
Calcium	,,	,,	4	,,	,,	,,	–	,, .. 4
Magnesium	,,	,,	2	,,	,,	,,	1	,, .. 3
Iron	,,	,,	–	,,	,,	,,	2	,, .. 2

Thus work on the above 12 sites suggests that the commonest deficiency is that of phosphorus, but that those of potassium, calcium and magnesium are also common. The fact that the two indications of iron deficiency were in crops containing excess calcium suggests that lime should be applied only in small quantities, if at all, on this soil and that limestone dust might be preferable.

These results raise the hope that work along these lines, together with leaf injection, might form the basis for advice that would lead to a considerable increase in yield on the red soils as a whole. Periodical tests on the same sites during the season might reveal whether the trouble is mainly inadequate application of fertilizers or whether heavy leaching in this high rainfall region on light soils results in a shortage of nutrients late in the season, when they are needed for formation of grain. Should this be so the cure would have to be brought about by a combination of increasing humus, using manures of not too rapid availability, and top dressings late in the season.

3. Mr. Large's Potato Demonstration Plots.—Mr. Large of Seale Hayne Agricultural College carried out Bordeaux spray demonstrations on a number of potato crops scattered over Devon and Cornwall, on a few of which he tried the effect of extra applications of potash and on all of which he made estimates of yields. He invited the team to make a mineral deficiency survey of these plots and he very kindly arranged for most of the transport. Miss Holmes took samples for analysis and did leaf injections on a number of these in the hope of finding evidence of deficiencies to account for any low yields. The results of this survey were disappointing in that little evidence of deficiency was obtained. This was not surprising in view of the yields which varied from 8·9 to 20·9 tons per acre.

Evidence of potash deficiency was obtained on the three lowest-yielding crops, the yields being 11·2, and 8·9 tons per acre respectively. On the first crop neither Mr. Le Riche's quantitative analyses nor the analyses done here revealed potash deficiency before leaf symptoms were definite, but leaf injections gave good responses before the appearance of symptoms.

The 9·5 tons per acre crop was affected by leaf roll virus disease. Affected plants responded to injections of the trace elements : iron, manganese and boron, and plants free from virus disease to iron only. The 8·9 tons per acre crop was affected by " dry weather leaf roll ", but was found free from leaf roll virus disease by Mr. Beaumont of Seale Hayne Agricultural College. Affected plants responded to injections of the trace elements, iron, manganese, zinc and boron.

4. Field Beans. Mr. Large also invited the co-operation of the team in work on field beans. Leaves gathered from plants with short internodes and bearing leaves similar to those illustrated in Wallace's (1943, 1945) colour atlas as characteristic of potassium deficiency were shown on analysis to contain less potassium than normal plants growing close by.

Similarly plants " characterized by thin, spindly growth, poor colour and small leaves " were found on analysis to contain less phosphorus than normal plants growing near-by.

In his more detailed report Mr. Large concludes : " It would appear from the above preliminary results that spectrographic analysis of leaf samples can be of very great assistance to us in regional survey and advisory work on the bean crop. Not only for the identification of suspected mineral deficiencies, but also for obtaining more positive information than has hitherto been available on the influence of mineral factors on the incidence of Chocolate Spot and other fungus diseases."

The Marshlands of Kent. Many thousands of acres of marshland in South Kent have been ploughed up during the war and a large fraction of this area has yielded disappointingly small crops. Furneaux and Glasscock (1936) from the South-Eastern Agricultural College, Wye, had shown that

peas grown over wide areas of the Marsh were affected by " marsh spot ", later shown by others to be the result of manganese deficiency; Dr. N. H. Pizer, also of Wye, had observed symptoms of manganese deficiency in other crops and had obtained striking results from experimental spraying. The present investigations followed directly on that of the Wye workers and in some of them Dr. Pizer and his colleagues co-operated.

1942.—Samples of cereal and potato leaves were collected for analysis and ten essential elements were injected into potatoes at a few scattered localities. Of these only manganese led to definite responses. Injections were therefore restricted to manganese alone, to cover as wide an area as possible and evidence of widespread manganese deficiency was obtained.

1943.—Dr. Pizer co-operated in an attempt to assess the extent and the degree of seriousness of manganese deficiency in terms of its effect on yield.

Potatoes.—The results of a replicated experiment on potatoes (var. Eclipse) suggested that manganese spraying led to an increase of $1\frac{3}{4}$ tons per acre over a field of 20 acres as a whole.

For the other crops a strip 10 links by 200 links was sprayed and its yield was compared with that of a similar unsprayed strip on either side of it. This simple comparison was repeated up to four times in each of a number of fields scattered over the Marsh, in such a way that nearly all the main soil types of the Marsh were represented.

Sugar Beet. One experiment on sugar beet gave no increase in yield in spite of an effect being apparent on the foliage.

Cereals and Peas.—The results for cereals and peas were as follows:

MAIN RESULTS OF SPRAYING CEREALS AND PEAS WITH MANGANESE SULPHATE
(Yields in cwt. per acre.)

	Not sprayed.	Sprayed.		Increase.	
		5 lb. p.a. $MnSO_4$	10 lb.		
WHEAT	3·1	8·6	8·8	5·5	5·7
	13·2	13·9	20·4	0·7	7·2
	31·8	35·9	36·3	4·1	4·5
	13·6	21·6	20·8	8·0	7·2
	34·3H	37·6H		3·3	
OATS	25·1	33·2		8·1	
	24·2	26·5		2·3	
PEAS	7·5	10·1		2·6	

H—Sprayed plots were more severely damaged by hares than unsprayed.

These results (seven of which are statistically significant) proved that manganese deficiency was both widespread and caused serious loss in crop yields.

Effect of spray on wheat showing no symptoms.—The two wheat strips, the yields of which were 31·8 unsprayed, and 35·9 and 36·3 cwt. per acre sprayed with 5 and 10 lbs. per acre manganese sulphate, and 34·3 unsprayed and 37·6 cwt. per acre sprayed with 5 lb. manganese sulphate per acre respectively, giving apparent increases due to spraying of 4 and 3 cwt. per acre with 10 : 1 and 5 : 1 odds respectively against the results being due to chance, were on crops that looked perfectly healthy. A careful search revealed no leaf symptoms of manganese deficiency and no effect of the spray was apparent in the growing crop.

In addition to the last mentioned strip another one was sprayed in the next field. At harvest time the straw on both the sprayed strips was of a definitely brighter, richer yellow colour than the unsprayed on either side. There was so much more hare damage on each sprayed strip as to suggest strongly that the hares had found the straw on the sprayed plants more palatable than the unsprayed on either side. The damage was so great on the one strip as to reduce its yield considerably, making a yield estimate unreliable. Further reference will be made to these areas when the 1944 results are considered.

Wheat, 1944. The above increases in crop, although substantial, are still insufficient to turn a bad crop into a good one. Dr. Pizer made detailed examinations of the soils and found no obvious reasons why all of them should not bear a heavy crop of wheat. In view of the possibility that the 1943 treatments might not have made good the manganese deficiency completely, the main object of

the work in 1944 was to determine the optimum spraying conditions. Experiments were therefore designed by Mr. Barclay to determine :

1. The optimum concentration of manganese sulphate.
2. Whether the use of a wetter is advantageous.
3. The best time of the year at which to spray.
4. Whether more than one spraying is necessary.
5. Whether the use of manganese hydroxide or carbonate would be advantageous by resulting in the manganese being liberated slowly and continuously for the use of the plant in the same way as copper is from Bordeaux mixture.

He carried out four experiments on wheat, two on nearly the same sites as those used for the experiments, the yields of which are given first and third respectively in the previous table, and the other two close together in the next field. These were selected to cover soils of a wide range of fertility. The yields of untreated plots were, in round figures, 20, 50 and 30 cwt. per acre, respectively. Thus the extreme range of yields from 20 to 50 cwt. per acre were given by two different plots in the same field. The medium yield came from the next field.

The plan of each experiment was a 7 by 7 latin square ; two of them had plots divided into 14 sub-plots, one into 10 and one into 8. Not all of the 2,000 odd samples of ears have yet been threshed ; consequently the following conclusions are based on ear weights, but there is excellent correlation between ear weight and grain weight.

Yield Increases.—Considerable increases in yield (8 cwt. or 14 bushels of grain on crops of 25, 45 and 70 bushels per acre respectively) were obtained.

Spraying Periods.—On the most deficient soils early spraying was essential, but this was less important on less deficient areas. Two sprayings at monthly intervals (mid-May and mid-June) were better than one.

Concentration and Wetter.—$\frac{1}{4}\%$ ($2\frac{1}{2}$ lbs. manganese sulphate in 100 gallons of water per acre) appeared to be the optimum for single and double spraying when no wetter was used ; whereas when wetter was used (liquid Agral $\frac{1}{1000}$) the best results were obtained with 1% or more for single and $\frac{1}{2}\%$ for double spraying in bad areas ; $\frac{1}{4}\%$ for single and $\frac{1}{2}\%$ for double spraying on less deficient areas, and 1% or more applied twice on the best areas.

Although none of the yield differences due to wetter were statistically significant, in every comparison the yield was greater when wetter was used than when it was not. There is little doubt therefore that the use of wetter is advantageous.

Slightly soluble manganese compounds.—The addition of a hydroxide or carbonate to the manganese sulphate, to produce a suspension of a slightly soluble compound from which manganese might be released slowly and be available to the plant as needed, led to no increase in the effect of the spray on crop yield.

General Conclusions.—The results lead to the same general conclusions as those drawn from the 1943 results, viz. : that, although considerable increases in yield have followed from spraying with manganese sulphate, these increases are not great enough to change a poor crop into a good one. The 1944 are better than the 1943 results in that, in 1944, the increases were larger, i.e. of the order of 10 cwt. per acre of grain.

Consideration of the detailed results raises hope of still greater increases being obtained by further modifications of treatment, e.g. earlier and more frequent sprayings and the use of higher concentrations of manganese sulphate. These further modifications are desirable both to get a more accurate measure of the effect of manganese deficiency on yield and to define the problem of making good the deficiency with maximum efficiency on a commercial scale. For example, should a sufficiently great further increase in yield result from increasing the number of sprayings, the possibility of another method of spraying would have to be considered, e.g. use might be made of the almost ubiquitous breeze on the Marsh to carry a mist produced by a machine moving along one headland to the rest of the field.

The limited success of the attempt to raise the yield of poor crops to the optimum also suggests the necessity of following up the indications to be mentioned later of deficiencies of other elements in addition to that of manganese.

Peas.—1943.—A simple spraying experiment carried out on peas gave most encouraging results both in increasing yield and in reducing marsh spot in peas.

1944.—In 1944, therefore, Mr. Barclay carried out a 7 by 7 by 7 by 2 experiment on peas similar to one of those on wheat already mentioned.

Effect on Yield and Marsh Spot.—Large increases in yield (16 cwt. on a crop of 17 cwt. per acre of shelled peas) and in the percentage of peas unaffected by marsh spot (raised from 68 to 98) were obtained by a single spraying with 10 oz. of manganese sulphate in 100 gallons of water (plus liquid Agral $\frac{1}{1000}$) during flowering.

Periods.—The sprayings were carried out :

1. When the plants were about 4 inches high.
2. At the commencement of flowering.
3. Mid-way in the flowering period.

The first spray had an effect at $\frac{1}{2}$ and 1% on yield and marsh spot when a wetter was used, but not in the absence of wetter.

The second spray had more effect at low concentrations on both yield and marsh spot when a wetter was used, but appeared to have no effect on marsh spot when a wetter was omitted. When a wetter was used, spraying at both period 1 and 2 reduced marsh spot more than either spraying alone.

Spraying at period 3 gave a greater effect than at periods 1 or 2, especially at low concentrations and in the absence of wetter, and more so on marsh spot than on yield.

The major effect on marsh spot was produced by spraying at period 3, i.e. during flowering.

Optimum Concentration.—In the absence of wetter irregular results were obtained from which no conclusions could be drawn in regard to the effect of concentration of spray. When wetter was used, however, there was little difference in efficiency between any of the concentrations tested, viz. : 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, and $\frac{1}{16}$% $MnSO_4$ except that for the late spraying $\frac{1}{16}$% seemed to be the best, and for the first only $\frac{1}{2}$ and 1% were effective. The 1% solution seemed to reduce marsh spot more than the more dilute solutions, especially when wetter was omitted.

General Conclusions.—The effects of spray in increasing yield and decreasing marsh spot were most satisfactory. The superiority of the spraying at the mid-flowering period over earlier ones was striking and in marked contrast with the results obtained on wheat.

Potatoes—1942.—The results of a simple field experiment suggested that spraying with 1% manganese sulphate led to an increase in yield of Majestic potatoes affected by manganese deficiency.

1943.—A replicated experiment on Eclipse potatoes showed no increase in yield from spraying a 12$\frac{1}{2}$-ton-per-acre crop, which showed few symptoms of manganese deficiency, in spite of having a visible effect on its foliage.

There was a significant effect on an area showing symptoms of manganese deficiency (the increase being 2·7 tons per acre) and it was calculated that the average increase due to spraying over the 20 acre field as a whole was 1$\frac{3}{4}$ tons per acre.

1944.—Crop increase from spraying Arran Pilot potatoes free from leaf symptoms.—The experiment was carried out on Arran Pilot potatoes which had every appearance of being perfectly healthy.

Symptoms.—There was no sign of patchiness in the 20 acres of crop as a whole and a careful search failed to reveal any symptom of manganese deficiency.

Leaf Injection.—Each of the three manganese injections gave a definite positive response. The green of the permeated parts of the leaves was the nearest approach so far obtained to the excessively dark green sometimes obtained as a result of nitrogen injection and corresponding with excess nitrogen.

Effect of Spraying.—Spraying raised the yield from 4 to 5 tons per acre (odds over 100 : 1) in spite of the crop being lifted very immature and in spite of the spray having little or no visible effect on the foliage.

Diagnosis by Injection and by symptoms and yield increase from spraying.—The work was carried out on potatoes of a variety (Majestic) in which the development of manganese deficiency symptoms is particularly satisfactory.

Leaf Injection.—Leaf injections done on 3.6.44 gave a definite response to manganese on 11.6.44.

Symptoms were first seen on 17.7.44 when the most advanced symptoms were thought to be less than a week old.

Date of Spraying.—The spraying was done on 19.7.44 and was carried out rather more promptly than a farmer could usually have done it if he had waited for the development of symptoms, because he could not be expected to make the thorough search made on this occasion.

Results.—The effect of spraying potatoes showing symptoms of manganese deficiency was compared with that on others showing no symptoms. The yield was increased on the areas where symptoms were present but not where they were absent. The mean yield of the unsprayed potatoes showing symptoms was 13·7 tons per acre and that of the corresponding sprayed potatoes 16 tons per acre. Spraying with $\frac{1}{4}$% $MnSO_4$, with wetter, gave a yield of 17·6 tons per acre, but $\frac{1}{2}$%, with wetter, gave 14·5 tons per acre, which was no better than that of the corresponding unsprayed areas.

Potatoes on sites where spraying appeared to increase the yield of wheat that showed no symptoms in 1943.—The two contiguous fields mentioned earlier in the report (p. 51), in which spraying appeared to increase the yield, were cropped in 1944 with Majestic potatoes. Toward the end of the

season these were examined for evidence of manganese deficiency. No symptoms were found on the first visit when leaf injections were carried out. The potatoes in the second field were probably too old to respond to injection but the attempt was made nevertheless.

On the next visit there were two definite responses from eight injections in the first field but no symptoms. In the second field, in which the potatoes were probably too old when the injections were done, there was no response, but three leaves were found showing the stippling on either side of the veins typical of manganese deficiency. These were the only symptoms found on the main level part of the field, but on a higher strip running parallel with the hedge separating it from the "cliff" there were severe symptoms of manganese deficiency.

Although the potatoes were much too old for spraying to be of anything approaching full efficiency, it seemed worth doing a small experiment as a further test for manganese deficiency. This Mr. Barclay did in both fields immediately after the above observations were made. Unfortunately blight appeared early. There were no symptoms of manganese deficiency on the first field when the first signs of blight appeared. In the first field the yield of sprayed plots was greater than that of the untreated, the odds being 4 : 1 against the result being due to chance.

All that may safely be concluded from these results is that these indications of mild manganese deficiency in potatoes are in harmony with the rather stronger evidence gathered in the same fields in 1943 on wheat showing no symptoms of manganese deficiency.

Carrots.—A 7 by 7 by 7 by 2 experiment on carrots (which, when the experiment was laid out, appeared to be making excellent growth uniformly over the whole of the area of some 10 acres) was started on an area which the foreman stated had produced inferior crops in previous years. Toward the end of the season the foliage became lighter than that of the remainder of the field, and later this area took on a slightly scorched appearance. But there were no symptoms recognized as specific of any mineral deficiency. Leaf injections carried out by Miss Holmes gave a slight but just definite response to manganese in two tests out of four.

There was no statistically significant effect of spraying, but the odds were 4 : 1 that spraying had reduced the crop to slightly below the general average of 19 tons per acre.

Mangolds.—Both in 1942 and in 1943 a particular field had borne a crop of mangolds which, during their whole period of development, showed most severe symptoms apparently of manganese and other deficiencies. The diagnosis of manganese deficiency was confirmed in 1943 by Dr. Plant of the Long Ashton Research Station. Yet a yield estimated at about 70 tons per acre was produced. In 1944 mangolds were grown in the next field, close to the site of the 1943 replicated wheat experiment and in an area on which potatoes were affected severely by manganese deficiency in 1942. These mangolds, like those of 1942 and 1943, developed severe symptoms in the four-leaf stage and remained severely affected throughout the season.

Leaf injections were carried out on plants taken at random and classified according to severity of the manganese deficiency symptoms, which are numbered below, the most severely affected being given the number 3.

The results were as follows :

Element.	Symptoms.	Result.	Element.	Symptoms.	Result.
Iron ..	3	+	Boron	1	?
	1	?		2	+
	3	—		2	·
	2	?		3	·
Manganese ..	3	+	Copper ..	3	·
	0	?		0	+
	2	+		2	—
	3	+		3	?
Zinc ..	3	+	Water	3	·
	2	?		1	+
	1	·		1	·
	1	+		2	·
			Nickel	0	·
				2	·
				2	·
				2	·

+ Positive response ; ? suspected positive response ; · no effect ; — negative response.

None of these responses was very striking, and in untreated plants there was much variation, some of which was distributed in a manner similar to the effects of injection. In view of these facts and of the apparent effect of a water injection, it would be unsafe to draw more than a tentative deduction from these results, namely, that there seemed to be a tendency towards trace element deficiency, especially to that of manganese.

Mr. Barclay carried out a 7 by 7 by 6 spraying experiment on the worst affected area and 32 replications of four treatments on the least affected area. The yield on the two areas was 50 and 50 tons per acre respectively. There was no significant effect of treatment. The excellent yield and the lack of response to spraying were not in harmony with the diagnosis based on the leaf symptoms, which, as already stated, were most severe.

Evidence suggesting deficiencies of other elements in addition to that of manganese.—The main aim of the work so far described, particularly that on wheat, was to determine how far the complete making good of manganese deficiency would change a poor crop into a good one. The results achieved, though better than those of 1943, do not encourage the hope of complete success along this line.

An alternative possibility is that yields are being lowered not only by manganese deficiency but also by deficiencies of other elements. As a first step in exploring this possibility leaf injections were done on a few crops in addition to those already mentioned.

Tests were made on the unsprayed and sprayed portions of wheat in the field in which two of the main spraying experiments were done (labelled below " wheat u " and " wheat s " respectively) ; on peas that had been sprayed twice with manganese sulphate ; and on Eclipse and Arran Pilot potatoes that had not been sprayed. These potatoes were growing next each other. The results were as follows :—

	Water.	N.	P.	K.	Mg.	Fe.	Mn.	Zn.	B.	Cu.	Ni.
Wheat u ..	····	?·?+	····	····	dddd	?··?	?++·	+·+·	?+?·	·++·	·+−+
Wheat s ..			·−+	++?		··++	++·+	?···	+++	?+++	−·+−
Peas ..		·++·	+·+?	?+?	····	·?++	++??	·+−−	+···	·+·−	+−+?
Potatoes E ..	····					····	+·+·	···?	····	++++	····
Potatoes A.P.	····					····	+++	····	····	····	····

\+ definite positive response. — negative response.
? suggestion of a response. d death of some leaf tissues.
· no response.

It will be noted that wheat, both when untreated and when sprayed with manganese, gave responses to the largest number of elements and was the crop the yields of which fell farthest below what the advisory chemist considers it should be capable of yielding in the areas concerned. Potatoes, which yield much more nearly optimum crops, responded to one extra element only, viz. : copper. This response to copper is interesting when considered in relation to the fact that sheep in this area are prone to " sway back ", a malady cured by the administration of copper.

It cannot be assumed that because an element on injection improves the colour of the leaf that a deficiency of it is reducing yield appreciably. Only direct experiments can test this possibility. These are being undertaken in 1945.

The Lake Bed at Bradbourne, East Malling.—The highly calcareous humus in the lake bed at Bradbourne presented the opportunity of growing plants close at hand under constant observation in soil already suspected of being deficient of trace elements. For certain purposes these advantages outweighed the disadvantage that results obtained on such an exceptional soil as this would be applicable only in a general way to any other soil.

Mangolds.—(For details see paper by Hoblyn and Roach (1945) that follows this.)

A spraying experiment was done in co-operation with Mr. Amos and the farm staff on a crop of mangolds growing in the lower half of the area.

Symptoms.—The mangold plants from an early age showed symptoms of manganese deficiency. This diagnosis was confirmed by Professor Wallace. The symptoms were much more severe on the lower central part of the area than on the higher parts near each bank of the original lake. Kale

plants amongst the mangolds, however, showed no signs of any mineral deficiency, in spite of the fact that kale is looked upon as a good indicator of manganese deficiency.

Diagnosis by Injection.—The results of leaf-stalk injections carried out by Miss C. C. Rhodes on plants on the lowest part of the area, where symptoms were most severe are as follows :—

	Water.	N.	P.	K.	Ca.	Mg.	Fe.	Mn.	Zn.	B.	Cu.	Ni.
1	....	....	.?..	....	....	....	....	++++	.?.?	....	....	....
2	....	....	....	...	...?	....	..?	?+.?	....	.. —.	....	....

1 Date of Injection, 23.6.44.
Date of diagnosis, 10.7.44.

2 Date of injection, 27.6.44.
Date of diagnosis, 13.7.44.

\+ positive response.
? suspected positive response.
· no effect.
— negative response.

The conclusion drawn from these results was that there was a definite but not very strong response to manganese but to no other element.

Effect of spray on foliage.—About a week after spraying with 1 per cent. manganese sulphate with spreader there was a definite improvement in the appearance of the foliage. The colour from a distance was greener on the sprayed plots than on the unsprayed. On close inspection the symptoms were less marked on the sprayed than on the unsprayed leaves.

Effect of spray on yield.—The yield on the untreated strips was highest in the middle where the symptoms were most severe, and the increase resulting from spraying was slight in the middle, where symptoms were most severe, but most marked at each end, where the symptoms were so slight as to be hardly noticeable.

The diagnosis by injection was reliable in that it suggested a manganese deficiency which was borne out by the slight increase in crop resulting from spraying the central area. Unfortunately no injections were done on the area practically free from symptoms but giving the maximum response to spraying. The leaf symptoms were completely misleading as judged by the effect of spraying on yield.

Comparison of symptoms and injection responses in different plants growing in the same soil.—(For details see paper by Garner and Roach (1945), p. 70 of this Report.)

The upper part of the lake bed had been used by Mr. Garner as a cutting bed in 1943. Rooting was uniformly excellent and growth was excellent in places but not so good in the middle. The middle low-lying part, where growth tended to be poorer, showed symptoms suggesting mineral deficiency. A few injections done late in 1943 suggested the same conclusion.

Accordingly in 1944 indicator crops suggested by Professor Wallace were planted alternately with different kinds of cuttings representative of those likely to be grown in the cutting bed.

These were :—

Quince A.
Willow.
Apple rootstock MI.
Blackcurrant.
Myrobolan B.
Gooseberry (Wisbech Careless).
Swedes.
Cauliflower.
Potato.
Mangolds.
Oats.

A few rows of peas were sown.

Results and Conclusions.—The most interesting observations from the present point of view were as follows :

Oats, willows and potatoes growing only a few feet apart in parallel rows made poorer growth in the middle where the symptoms were also most severe. Manganese deficiency was diagnosed in both oats and potatoes by leaf injection and confirmed in the oats by spraying. The willows however, gave strong responses to all four iron injections but no response to any of the four manganese injections. The response to iron consisted in one side of the leaf being of a perfectly healthy appearance in marked contrast with the untreated half, which showed chlorosis associated with poor growth wherever it occurred on the plot. The symptoms on all three plants were diagnosed by Professor Wallace as those of manganese deficiency. This was the first time Professor Wallace had seen these symptoms in the willow and he diagnosed them on their close similarity to those of manganese deficiency in

fruit trees. The injection results suggest that it may be unsafe to diagnose a new kind of plant on the basis of the general character of the symptoms.

Another example was furnished by a Boysenberry plant (a *Rubus* hybrid) growing on the plot. This showed the type of chlorosis characteristic of iron deficiency in a number of kinds of fruit trees and this was exhibited mainly on the leaves at the tip of the shoot, a character also usual in iron deficiency. A spraying test by Mr. Garner, however, proved the deficiency to be that of manganese.

Comparative Earliness of Diagnosis by Symptoms and Leaf Injection in the Potato.—A watch was kept for the development of leaf symptoms on four representative potato leaves that responded to manganese injection. Two of these developed mild symptoms of manganese deficiency eight days after the response to injection was quite clear cut. This advantage of eight days of injection over symptoms is in harmony with experience in the field. The remaining two leaves developed no symptoms at all. One was watched until it turned completely yellow. The other was preserved when senescence began.

Development of leaf symptoms of manganese deficiency on the potato plant.—The above results and general observations of potato plants suggest that the first few leaves of a potato plant, even when growing under conditions of extreme deficiency, neither respond to injection nor develop symptoms later. Probably the reserves of manganese in the parent tuber are enough for these first few leaves. The later leaves respond to injection but do not develop symptoms. Still later leaves respond to injection and about 8 days later develop specific symptoms. In succeeding leaves the symptoms tend to develop earlier in the life of the leaf and the advantage of injection over symptoms becomes progressively less.

Relation between severity of symptoms and yield in Potatoes.—The potatoes were lifted carefully by hand and the tubers from each hill were weighed separately. An examination of the resulting figures (see Garner and Roach, 1945, p. 70) revealed that the yield decreased as the symptoms increased in severity, in harmony with the results obtained in the Marsh in 1942, but diametrically opposed to those obtained on mangolds in the other end of the lake bed.

Work on Commercial Fruit Plantations.—Advisory officers and individual growers have consulted the team on many occasions about faulty performance of trees. Work on these has consisted mainly of leaf analyses, supplemented when possible by personal visits to do leaf injections or leaf paintings. The main results obtained have been summarized by Roberts and Thompson in separate reports. These illustrate how results of soil analysis, leaf analysis, injection, leaf painting (Roberts, 1945 (*a*)) and leaf symptoms supplement each other and so form a system capable of rapidly elucidating complicated nutritional disorders in plants.

Multiple deficiencies of potassium and trace elements.—A widespread and serious deficiency of potassium was found in fruit trees which appears to be rapidly getting worse owing to lack of potash manuring during the war. With this was commonly associated trace element deficiency, often resulting from, or enhanced by, applications of lime (Roberts, 1945 (*b*)).

This work illustrates how leaf analysis and leaf injection may be used as complementary methods. Leaf symptoms alone were not sufficiently definite to form the basis of more than a tentative diagnosis. Leaf analysis confirmed and extended these tentative diagnoses, after which the symptoms could be used for finding similar cases, which in turn could be tested further by leaf analysis and later by curative injections.

Simple and Multiple Trace Element deficiencies in Cherries.—In another Report, Thompson and Roberts (1945), p. 60, describe work on two serious troubles in cherry orchards. The first type of trouble is common in the main cherry growing area of Kent and is due to manganese deficiency. It is now under commercial control by tree injection. In preliminary experiments spraying with manganese solution, either in summer or winter, cured the trouble for the current growing season.

The second trouble proved to be of a more complex nature. Leaf symptoms suggested the possibility of both manganese and iron deficiencies, but a definite diagnosis could not be based on symptoms alone. Leaf analysis revealed low contents of both manganese and iron and, in addition, of zinc, a deficiency of which was not suggested by symptoms. Experimental injection confirmed all three deficiencies and proved that a complete cure was not brought about unless all three elements were given.

Special Methods for Enriching Seeds with Minerals before Planting in Deficient Soils.—When the food situation was most acute, Mrs. Roberts started work on two methods aimed at increasing the mineral content of seed before planting in deficient soils. These consisted in allowing the seed to absorb a solution of the mineral, introduced into a hole bored in the "seed" tuber of the potato and by simple soaking of grains.

Tuber Injection.—The fact has been established that enough nutrient, both major and trace, can be introduced safely into the "seed" tuber to affect materially the yield of the resulting crop. Attempts were made to evolve an injection method that could be used on a large scale, but in 1944

work along this line was slowed down in favour of the soaking of seed grain which appeared much more likely to be of practical value.

Seed Soaking.—The method consists in soaking the grain in about a third of its weight of solution. To obtain the best results it is important not to use more solution than the seed will absorb. The grain must be dried at a low temperature.

Experiments were done on oats, wheat, barley, beans and peas with solutions of both major and trace elements.

The most hopeful results were obtained on seeds soaked in phosphate solution and sown on soils with a high tendency to fix phosphate.

In an experiment done in co-operation with Professor Robinson (of University College of North Wales) on a farm near Bangor, oats soaked in tribasic potassium phosphate raised the yield from 17 cwt. per acre (a normal yield for this area) to 25 cwt. per acre, an increase of 8 cwt. per acre resulting from the use of $13\frac{1}{2}$ lbs. potassium phosphate (4·6 lb. P_2O_5). It is doubtful whether this increase in yield could be obtained by the application of much larger amounts of phosphate to the soil even with the use of a combine drill.

There are large areas of similarly deficient soils in the West of England, West Wales and Scotland where oats are of primary importance, and where this method should bring about similar large increases in yield. The method is simple enough for the farmer himself to employ, the drying being the most difficult part of the operation. Seed merchants who have drying kilns could treat seed for a whole district in bulk ; if this were done great care would have to be exercised not to allow the temperature to rise too high, because the grain is very sensitive at high moisture content.

General Conclusions.—The results of the work just described lead to the conclusion that plant analysis and plant injection have a wide field of usefulness for diagnosing mineral deficiencies in crop plants. They are particularly applicable to trace elements, which cannot at present be dealt with by soil analysis and they have revealed deficiencies of both major and trace elements of primary economic importance in crops showing no symptoms from which the deficiencies could be diagnosed.

Deficiencies may usually be diagnosed by analysis and injection before characteristic symptoms appear. This allows extra time for arrangements to be made for curative treatments and gives them an extra chance of exerting their full effect in the current season.

Applied to the widespread manganese deficient areas of the Marshlands of Kent, these same methods revealed the deficiency in wheat, potatoes and peas before the characteristic symptoms developed. Time thus saved is important in allowing the farmer to arrange early spraying, which is essential, except perhaps for peas. Indeed, in some areas in which symptoms never appeared, leaf analysis and leaf injection revealed a deficiency of manganese which was confirmed by three experiments in which spraying with manganese sulphate increased the yield of wheat from 32 to 36, 34 to $37\frac{1}{2}$ and from 47 to 56 cwt. per acre respectively, with odds that the increases were not due to chance of 10 : 1, 5 : 1 and 6 : 1 respectively. As these were the only experiments of the kind, it is permissible to combine them, when the odds become 300 : 1 that the results were not due to chance.

Plant analysis and plant injection are also of value when used in conjunction with soil analysis and leaf and other symptoms. Examples have been given of tentative diagnoses based on symptoms being tested and extended by leaf analysis and injection. In general plant analysis and injection may be used to test the specificity of symptoms in representative plants, and symptoms may be used to map out the affected areas.

Certain of the results emphasize the importance of testing the validity of diagnoses by measuring the effect of curative treatments on yield in the field. The most striking example was afforded by manganese deficiency symptoms in the mangold. The most severe symptoms yet seen by the writer were on the largest crop he has ever seen (over 60 tons per acre). In an area of field yielding 50 tons per acre a replicated experiment failed to establish a significant increase in yield from spraying. In an experiment in another district symptoms were more severe on the higher yielding areas and *vice versa* and the increase in yield resulting from spraying was higher on the areas where the symptoms were less marked. So far diagnoses based on leaf analysis or injection have not proved misleading, but it will be necessary to test them over a period of years to assess their degree of reliability in this respect.

In the Marsh there was a close correlation between severity of symptoms and low content of manganese in the leaf on the one hand and yield on the other in wheat and potatoes. Although remedial treatments brought about most encouraging increases in yield the results do not encourage the hope that the yield of poor areas could be raised to that of the best areas by making good the manganese deficiency alone. Injection results suggest deficiencies of other trace elements (copper in potatoes and copper, iron, zinc, boron and nickel in wheat). The degree of importance of these is being tested in terms of yield increases resulting from treatment.

These results on manganese deficiency suggest that trace element deficiency reduces the yield

f a crop seriously without producing any specific symptoms, as has long been known to be true of eficiencies of the major elements.

These complementary methods of leaf analysis, leaf injection and curative tests under field onditions are applicable to most, if not all, agricultural and horticultural crops and seem capable f pointing the way to considerable increases in crop, not only on areas where yields are bad, but also ver much wider areas where crops are good on present standards, but might be made better, if nsuspected deficiencies were made good. Together with soil analysis and a study of plant symptoms, eaf analysis and leaf injection form complementary methods for the diagnosis of mineral deficiency,

Acknowledgements.—As already stated, this communication summarizes three years' work f a joint team drawn from the East Malling Research Station and the Research Institute of Plant hysiology, Imperial College of Science and Technology. The various constituent pieces of work vill be published in detail in due course. In the meantime only indications of the general fields of ork of the various members will be given.

Drs. Bolas and Goodall have been concerned mainly with physiological aspects of the diagnostic nethods and were responsible for the quantitative part of the flame method of spectrochemistry ised.

Major Thompson has been engaged on the development of new spark methods and on the use of rc methods of analysis.

Mr. Riches has been responsible for the polarographic work and methods for estimating iron and oron, assisted by Miss Parker.

Mr. Maynard did the field work in the Marshlands of Kent for the first season ; in the autumn Mr. Legg laid down field experiments both in Kent and Devon after which Mr. Barclay took charge f the field work and was assisted from the following spring by Miss Holmes. Miss Champion assisted vith field work at Malling in 1944.

Mrs. Roberts, who did much of the early diagnostic work in Devon, was responsible for the tuber njection and seed soaking work and shared with Major Thompson the routine diagnosis of the large number of samples analysed and the field work on mineral deficiencies in fruit.

The spectrochemical analyses and much other work were carried out by the Misses Ford, Martin, Kidwell, Macnamara, Gandon, Hook and Arnup.

Much of the photographic work was done by Mr. Lavender, and the construction of apparatus by the laboratory assistants Woolard and King, now on military service.

Much valuable assistance is gratefully acknowledged from voluntary workers, especially in the rush of harvest work, from Dr. B. M. Roach, the Misses Roach, Grayson, Mence, Nicholson and Dr. Wacowicz. A special debt of gratitude is owed for the co-operation and kindness of all on whose land these experiments were carried out.

Summary.—Leaf analysis and leaf injection have been used on agricultural and horticultural crops during the war for the diagnosis of mineral deficiencies, the effects of which on yield have been measured by experiments carried out under practical conditions in the field.

Widespread partial and complete failures in potatoes on freshly ploughed derelict land were shown by these two methods to be associated everywhere with calcium deficiency and in most places with magnesium deficiency also, though neither could be diagnosed by leaf symptoms. Making good the deficiency led to an increase of crop in 1943 of 3,000 tons on these derelict lands alone.

Manganese deficiency was diagnosed in wheat that showed no symptoms and spraying increased the yield to an economically important amount.

The yield of early potatoes, showing no symptoms, but in which manganese deficiency was diagnosed by leaf injection, was increased from 4 to 5 tons per acre.

These results prove that at least one trace element deficiency may reduce the yield of a crop to an economically serious extent without showing any specific symptom, as has long been known to be true of deficiencies of the major elements.

Widespread and severe deficiencies of potassium and one or more of the trace elements iron and manganese were diagnosed in apples.

Deficiencies diagnosed in cherries included a multiple one of manganese, iron and zinc, all three of which had to be injected to produce a complete cure.

References

Furneaux, B. S., and Glasscock, H. H. (1936). "Soils in relation to Marsh Spot of Pea Seed." *J. agric. Sci.*, **26**, 59-84.

Goodall, D. W. (1943). "Studies in the diagnosis of mineral deficiency. 'I. The distribution of certain cations in apple foliage in early autumn.' *J. Pomol.*, **20**, 136-43. 'II. A comparison of the mineral content of scorched and healthy leaves from the same apple tree.' Ibid., **21**,

90-102. "III. The mineral composition of different types of leaf on apple trees in early summer.'" Ibid., **21**, 103-107.
GLASSCOCK, H. H. and WAIN, R. L. (1940). "Distribution of Manganese in the pea seed in relation to Marsh spot." *J. agric. Sci.*, **30**, 132-40.
HORNE, F. R. (1943). "Experimentation on Land Reclamation. Devon." *J. R. Agric. Soc. Eng.* **104**, 90-100.
ROACH, W. A. (1938). "Plant Injection for diagnostic and curative purposes." *Tech. Commun.* 10, *Imp. Bur. Horticulture and Plantation Crops.* Obtainable from I.A.B. Central Sales Branch, Penglais, Aberystwyth. 5s.
——— (1939). "Plant Injection as a physiological method." *Ann. Bot. N.S.*, **3**, 155-226.
——— (1940). "Diagnosis of Mineral Deficiencies and Excesses by Systematic Leaf Injection and Analysis." *Rep. E. Malling Res. Sta. for* 1939, 51-8.
——— (1944). "The present position regarding the diagnosis of mineral deficiencies in fruit trees by plant analysis and plant injection." *Rep. E. Malling Res. Sta. for* 1943, 00-103.
——— and ROBERTS, W. O. (1945). "Further work on plant injection for diagnostic and curative purposes." *J. Pomol.*, **21**, 108-119.
(Reprinted as *Tech. Commun.* 10. *Imp. Bur. Horticultural and Plantation Crops.* Obtainable from I.A.B. Central Sales Branch, Penglais, Aberystwyth. 1s. 6d.)
ROBERTS, W. O. (1945 (*a*)). "Leaf painting as a method of diagnosis of mineral deficiency." *Rep. E. Malling Res. Sta. for* 1944, 67.
——— (1945 (*b*)). "Combined mineral deficiencies in fruit trees. Ibid., 64-67.
STAPLEDON, Sir R. GEORGE (1935). "The Land now and to-morrow." Faber and Faber, pp. 122-3.
THOMPSON, S. G. (1940). "The study of Mineral Deficiencies and Excesses by Spectrochemical Methods." *Rep. E. Malling Res. Sta. for* 1939, 86-7.
——— and ROBERTS, W. O. (1945). "Progress in the diagnosis and cure of mineral deficiencies in cherries." *Rep. E. Malling Res. Sta. for* 1944, 60-63.
WALLACE, T. (1943). "The Diagnosis of mineral deficiencies in plants." A colour atlas and guide. Pub. H.M. Stationery Office. 10s. pp. 116, 114 coloured plates.
——— (1944). Supplement to above. pp. 9 + 94 plates in colour.

PROGRESS IN THE DIAGNOSIS AND CURE OF MINERAL DEFICIENCIES IN CHERRIES

By S. G. THOMPSON and W. O. ROBERTS

THE diagnosis and cure of serious deficiency of manganese in cherries by injection methods has already been reported by Duggan (1943). Further progress in this work will now be described, including the results of preliminary attempts to cure the trouble by summer and winter spraying.

In addition the diagnosis and experimental cure of a complex deficiency, viz. of manganese, iron and zinc, will be described.

1. Manganese deficiency in the Sittingbourne district.—The Sittingbourne district has been noted from Roman times as the best cherry growing area in Britain, and from the Middle Ages to the present day cherry orchards in this district have been of high capital value. Some of the most valuable orchards, however, showed progressing deterioration marked by gradually diminishing crops and increasing chlorosis and dieback. It was a feature of this trouble that liberal manuring and skilled management did not prevent it: no remedy was known, and in the worst cases orchards were grubbed.

Preliminary work at Rodmersham by Roach and Levy (1937) showed negative results from injections of iron, but some improvement from driving iron nails into the trunk, and from digging in turf around trees. Further work by Duggan and others on a similar case in an orchard at Bapchild, near Sittingbourne proved that the deficiency was of manganese and that rapid recovery of the normal green colour of foliage and resumption of cropping followed the injection of suitable doses of solid manganese salts (Duggan, 1943). Since the results of solid manganese injections at Bapchild have been confirmed at Rodmersham and elsewhere, this technique has been taught to growers in the Sittingbourne district and is being generally used. There was some gumming from injection holes and it was clear that some growers would prefer a manganese spray if this were equally effective.

The effect of sprays on chlorotic trees at Rodmersham was therefore tested. It was known that manganese sprays at or after petal-fall gave good results, but there are objections to adding manganese

ulphate to the routine lime-sulphur spray and an additional spray at this very busy season was undesirble ; a winter spray which could be applied when work was less urgent was therefore tried.

Experimental. The following sprays were applied in February to one branch of each of seven rees, chosen so that two or more control branches should be adjacent to each branch sprayed :—

1. 16% Manganese sulphate.
2. 4% ,, ,,
3. 1% ,, ,,
4. 0·25% ,, ,,
5. Manganese Burgundy. (8 lbs. manganese sulphate, 10 lbs. washing soda, 40 gallons water.)

The trees were visited monthly, but no effect was noted before May, and effects only became bvious in mid-June. No damage was caused by any of the sprays. The observations given in the bllowing table were made on 15th July, 1944.

Effect of Winter Spray. Cherries at Rodmersham.

Tree.	Manganese Sulphate.				Manganese Burgundy.
	16%	4%	1%	0·25%	
1.	Perfect.	Very good.	Fair.	Slight.	Slight.
2.	Good on older leaves.	Perfect.	Good.	Fair.	Good.
3.	Very good.	Good.	——	Slight.	——
4.	——	Good.	Fair.	Slight.	Slight.
5.	Perfect.	Fair.	Slight.	Slight.	——
6.	Perfect.	Good.	Fair.	Slight.	Good.
7.	Very good.	Very good.	Slight.	Good.	doubtful.

(This tree had only very slight chlorosis and comparison with controls was difficult.)

Key.

Perfect.	Colour, appearance and size of leaf best possible.
Very good.	Very marked improvement on control.
Good.	Marked improvement on control.
Fair.	Improvement on control but chlorosis still evident.
Slight.	Slight improvement on control but chlorosis still evident.
——	Branch not recorded.

Green Bud Spray.—In one case of manganese deficiency elsewhere a complete cure in the current season was obtained with a 5% manganese sulphate spray at the green bud stage.

Early Summer Spray.—Other branches at Rodmersham were sprayed in mid-May with 3% manganese sulphate. The effect at 15th July was a definite improvement on controls, but not as marked as the improvement by a 4% winter spray.

Effects of 1944 sprays seen in 1945.—In June, 1945, only slight improvement when compared with control was noted in one branch sprayed with 16% manganese sulphate in February, 1944.

It is concluded that a winter (February) spray at, say, 5% will give a control of chlorosis in the current growing season which is better than that given by a summer spray, but that the effect will not be evident in the next year.

2. Multiple Deficiencies in Cherries in Sittingbourne area.—The manganese deficiency cases occurring on typical Sittingbourne brick-earth soils have, as mentioned above, definite symptoms, and can, as far as is known at present, be completely cured by treatment with manganese salts since no other deficiency appears to be involved.

The case to be described, though in the Sittingbourne district, had different symptoms and is located on a soil series, not yet identified, which may not be the same as the Rodmersham soil.

Symptoms.—The foliage was a dull yellow showing no pattern, neither that characteristic of manganese deficiency nor the fine pattern of veins described by Wallace as characteristic of iron deficiency in sweet cherries, and there was no scorching or necrosis : in general the symptoms were too indefinite to allow of the diagnosis of any particular deficiency. Apples interplanted with the cherries appeared healthy and had no deficiency symptoms.

Experimental. 1944.—Analysis of leaf material indicated that iron, manganese and zinc were low, calcium high, and potash and phosphorus normal. Leaf paintings in June gave responses to both iron and zinc. Solid injections of single large branches in June gave in the case of *iron* a response in one month and a striking response in two months, with complete return of green colour of foliage

FIG. 1.

Solid Injection with ferrous sulphate in cherry. Sample shoots taken from the same tree in late August, 1944.

(*a*) Control.
(*b*) Injected, June, 1944.

FIG. 2.

As Fig. 1. Samples taken February, 1945.

FIG. 3.

Solid injection in cherry with manganese, ferrous and zinc sulphates and boric acid, in August, 1944. Sample branches taken from the same tree in June, 1945.

(*a*) Control.
(*b*) Injected.
Note amount of growth.

contrast to the very chlorotic foliage in the rest of the trees (Fig. 1) ; some growth against none on untreated branches ; and an increase in bud production was noted (Fig. 2). There was also premature defoliation of the uninjected branches. The injection of *manganese* gave a recognizable response only after three months, when the leaves of the treated branch were definitely improved as compared with the control, but did not fully regain normal colour as with iron.

Similar injections in July gave definite responses to iron, and doubtful response to manganese and zinc. Responses were also obtained to sprays containing iron and manganese.

In the early summer of 1945, the branch injected with iron which had given a very striking response in 1944 was still better in leaf colour than the remainder of the tree and had set more fruit following the increased bud production noted in the previous autumn (Fig. 2), but considerable chlorosis had returned, thus indicating that iron alone would not give a complete control.' The branch injected with manganese, which had given a delayed and not very striking response in 1944, was now better in leaf colour than the rest of the tree, as was also a branch injected with zinc for which only a very doubtful response was recorded in 1944 ; a branch injected with boron in 1944 showed no improvement. It was noted that leaves from these branches injected with iron, manganese and zinc respectively all showed chlorosis, which on careful comparison differed slightly from each other and from that of leaves of control branches.

A branch injected with iron plus manganese in 1944 had foliage of dark green colour better than that produced by either element alone, but still showing a slight deficiency pattern.

A branch of a very chlorotic tree in bad condition, injected in 1944 with iron, manganese, zinc and boron, gave no obvious response in 1944, but in 1945 this branch was in complete contrast to the rest of the tree, having full foliage of good colour with no sign of chlorosis and a full crop of cherries, whereas the rest of the tree was still very chlorotic, with sparse foliage and a smaller crop (Fig. 3).

As regards new growth, it was observed that growth occurred in 1945 on the branches mentioned above injected with iron, manganese, zinc and boron (Fig. 3), with iron and manganese, and with iron only ; but no growth followed the injection of manganese only.

In February, 1945, as it was then considered on the previous year's observations that iron was the major deficiency, manganese the secondary deficiency and zinc a minor and perhaps unimportant deficiency, a series of trees was given whole tree injections of iron, of manganese and of iron plus manganese, with the object of getting a measure of the relative importance of the two deficiencies. At the same time, two other series of trees were given dormant sprays of iron, and of manganese, with the object of comparing the effects of injection with winter sprays.

At the time of writing, the injections of iron plus manganese have given the best results, both iron and manganese alone have produced considerable improvement, iron sprays have given some improvement but much less than injection, and manganese sprays seem to have had no effect.

A further series of trees has been injected with iron, manganese and zinc sulphates in June, 1945, with the intention of effecting a complete cure, and the effect of this and the other treatments mentioned will be observed in 1946.

Discussion.—The two cases reported above differ in that the first is a deficiency of a single element which can be controlled by sprays or injection of that element without difficulty on a commercial scale ; while the second is a complex deficiency of three elements, all of which must be supplied to effect a complete cure.

Errors are not likely to be made by persons skilled in diagnosis by leaf symptoms when dealing with simple cases of the first type, but if cases of the complex type are common, which is not yet known, leaf symptoms alone appear to be an unreliable guide. In the case reported, the leaf symptoms were indefinite and puzzling : iron and manganese deficiencies were at least suspected, but the existence of a zinc deficiency also could not be guessed. It is unlikely therefore, that a diagnosis by symptoms could have suggested anything more than a partial cure, and when such complex problems are met, other means of diagnosis seem essential.

Summary.—A case of manganese deficiency in cherries and experiments with curative winter sprays are reported. A case of multiple deficiencies in cherries is also reported where diagnosis by leaf symptoms needed to be supplemented by other diagnostic methods. Leaf analysis suggested deficiencies of iron, manganese and zinc, and this was confirmed by injection experiments. It was shown by solid injection that all three elements were required for a complete cure.

References

Duggan, J. B. (1943). "A promising attempt to cure Chlorosis, due to Manganese Deficiency, in a commercial cherry orchard." *J. Pomol.*, **20**, 69-79.

Roach, W. A., and Levy, B. F. G. (1937). "Iron Shortage Chlorosis in the Plantation. A Progress Report." *Rep. E. Malling Res. Sta. for* 1936, p. 153-9.

COMBINED MINERAL DEFICIENCIES IN FRUIT TREES

By W. O. ROBERTS

A SEVERE and serious deficiency of potassium, combined in most cases with a deficiency of one or more trace elements has become evident during recent years in many widely separated parts of England, chiefly in apple, but also in pear and plum trees. Unless speedy and appropriate action is taken, large numbers of trees seem likely to die. How widespread the trouble is may be gathered from the distribution map in Fig. 1, in which are indicated the locations of the cases so far known.

The circumstances of their diagnosis will be stated briefly because they suggest that many more may be escaping correct diagnosis.

The investigations of these combined deficiencies started in 1943, when six sets of leaf samples from apple trees proved on analysis to be deficient in potassium and a trace element, and in two of the

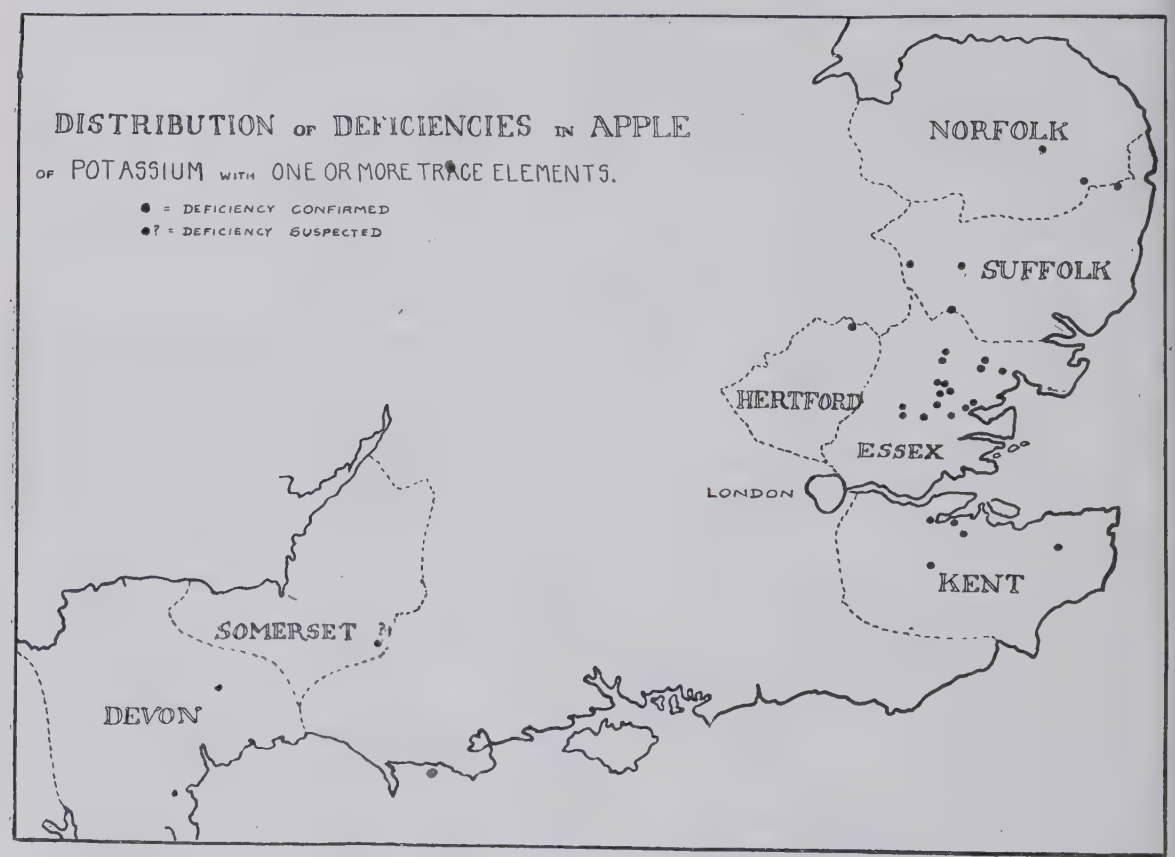


FIG. 1.

cases " die-back " was serious. In early June, 1944, two more sets of leaf samples from apple trees suffering from severe die-back proved on analysis to be deficient in potassium, iron and manganese.

Shortly after receiving the last two samples, the writer happened to be present at a meeting of Essex fruitgrowers at which serious concern was expressed about a widespread dying-back of apple trees. Advice had been sought in many quarters but no explanation was forthcoming.

Another case, where this trouble had occurred suddenly within a season and in a very severe form, was discovered as a result of her accompanying another worker when he examined the excavated root system and the soil to test the possibility of imperfect drainage or root disease as a cause of the die-back. No evidence was found to support either of these hypotheses and a week or so later the possibility of drought was tested by other workers by watering and mulching, as was also that of fungal or bacterial causes by an examination of dead branches. The following observations were noted by the writer on trees in the area where the die-back was serious :—

(*a*) Marginal scorch of basal leaves of extension shoots suggestive of potassium deficiency. (Wallace, 1943.)

(*b*) Interveinal chlorosis of the same leaves and of others on trees elsewhere in the plantation suggestive of manganese deficiency. (Wallace, 1943.)

(*c*) A chlorosis of the tip leaves of extension growths suggestive of iron deficiency. (Wallace, 1944.)

(*d*) Most of the leaves were small, brittle, and dull grey-green and had curled margins.

This tentative diagnosis of potash, manganese and iron deficiency was supported by the analytical results obtained just previously on leaves from sample branches sent from Hertfordshire, showing closely similar symptoms. But these symptoms, particularly the marginal scorch and interveinal chlorosis were so similar to those associated with drought (a possibility, as 1943 and 1944 were unusually dry seasons) that no diagnosis by leaf symptoms alone could be relied on without supporting evidence from leaf analysis.

Mr. O. G. Dorey very kindly arranged for the writer to visit all the plantations in Essex known to be similarly affected. The same leaf symptoms and die-back were exhibited in varying degrees of severity in all the thirteen plantations visited. Leaf samples were collected for analysis and they all agreed in indicating a combined deficiency of potassium and one or more trace elements.

Later in 1944 eight more similar deficiencies were diagnosed in apple in widespread parts of the country, making a total of 27 (6 in 1943 and 21 in 1944) combined deficiencies of potassium and one or more trace elements. Five similar cases in Conference pear and two in plum have been brought to the writer's notice.

Soils.—Most cases occurred where the soils were light and poor in their water holding capacity, but in three of them the soil was heavy clay and had only recently been drained. The dying back occurred in patches in the orchards.

Varieties affected.—From the evidence collected varieties appear to differ widely in their susceptibility. Those mostly affected are :—

Cox's Orange Pippin.	D'Arcy Spice.
Worcester Pearmain.	Newton Wonder.
Ellison's Orange.	Miller's Seedling.
Blenheim Orange.	Bramley's Seedling.
	Monarch.

Other varieties such as Early Victoria and James Grieve, growing next to trees exhibiting die-back symptoms, showed only severe leaf symptoms but no die-back.

Progress of the Deficiency Symptoms.— *Apple.*—Three stages were distinguished in 1944 in the progress of the deficiency.

1. The leaves were small, brittle and grey-green and the fruit was usually small. The young wood tended to be grey and often growth was poor. The whole trees lost that lustrous green vigorous look indicative of health and this condition became worse as the season progressed.

2. The basal leaves of extension growths became discoloured and showed marginal scorch and rolling ; there was interveinal chlorosis of spur and other leaves, and a yellowing of leaves at the tips of extension growth shoots ; branches about to die showed a blistering and wrinkling of the bark which was a most unnatural colour.

3. Die-back began and its progress was rapid. In some varieties, e.g. Cox's Orange Pippin, the die-back spread uniformly from the tips along the branches including lateral growths. In late summer there might be a proliferation of shoots formed at the base of the die-back portion but these too eventually died. In other varieties, e.g. Worcester Pearmain, the lateral shoots died back first and most of these were dead before the main branches commenced to die.

In those cases reported in May, 1945, leaves and flowers had developed and in some the fruit had set ; whole branches died in a fortnight or three weeks.

Pear.—The edges of the leaves became dark brown or black, the symptoms being similar to those described by Wallace (1944) as due to potash deficiency. The leaves were small and brittle and the edges curled parallel to the midrib. Some had a pinkish tinge. The bark became blistered and of an unhealthy colour and when lifted showed a blackened area round the base of the leaf stalk.

Dying-back sometimes occurred suddenly from the tips of branches which had produced a normal number of leaves and flowers.

Preliminary Curative Injection Work on Apple.—In 1944 the trees used for this preliminary trial were in a mixed clean-cultivated orchard which had received heavy dressings of lime, but no potash had been applied since 1939. The leaf symptoms were those already described and many lateral growths and branches were dead.

Analysis of the leaves confirmed the diagnosis from symptoms. Single branches were injected by the solid method (Roach and Roberts, 1945), using the anhydrous potassium sulphate at three

times the dose worked out by Bennett (1931) for trace elements and 1 gm. tablets of ferrous and manganese sulphate at the trace element dose.

Single branches were injected with :—

1. Potassium sulphate.
2. ,, ,, +ferrous sulphate.
3. ,, ,, +manganese sulphate.
4. ,, ,, +ferrous sulphate+manganese sulphate.

The selection of these branches and their corresponding untreated ones was done at random on comparable branches. Three weeks later the following observations were made :—

1. The symptoms had become more severe on all the untreated branches.
2. In the branch receiving potassium sulphate there was no further development of potash deficiency symptoms, but those of iron were markedly accentuated in the tip leaves.
3. On the branch receiving both potassium sulphate and ferrous sulphate there appeared to be complete recovery.
4. On the branch receiving potassium sulphate and manganese sulphate recovery was nearly complete.
5. The combination of all three substances had caused damage.

Further similar injections are being done elsewhere. In these experiments the maximum safe dose of potassium that can be given by this method is being determined. Results so far obtained suggest that nine times the dose given by Bennett for iron can be given in the form of anhydrous potassium sulphate and six times in the form of potassium phosphate, K_2HPO_4.

Discussion.—The following points are worth mentioning :—

1. No record has been found of combined deficiency of potassium and one or more trace elements, but results reported by Goodall (1943) are in harmony with such a diagnosis.
2. In all of the instances mentioned the iron content is below normal and in twenty-one of them the figure is less than half the normal.
3. The chlorosis affected only the leaves on the terminal three inches of shoot and the degree of yellowing did not correspond at all closely with the iron content.

Many of these trees are in such a bad condition that soil applications of potash, being relatively slow acting, are unlikely to save them. Injection experiments are therefore being undertaken in an attempt to bring about an immediate improvement to last until the soil applications can exert their effect. Solid injections have not in the past been tried for major elements because of the relatively small amounts that can be introduced in this way, but in view of the encouraging results noted above a number of trials are being carried out.

The apparent prevalence of potash deficiency is not surprising in view of the small quantities of potash available for fruit during the war. In most instances concerned with in this note no potash has been applied since 1939. Some of the plantations were on naturally calcareous soils, but the majority had received heavy calcareous dressings. These facts probably explain the occurrence of trace element deficiency and suggest that extreme caution should be exercised in the application of lime to fruit trees.

Acknowledgements.—Special thanks are due to Dr. W. A. Roach for his help and advice; to Messrs. Dorey and Landau, Essex Horticultural Officers; to S. G. Thompson, East Malling Research Station and to the many growers concerned for their practical co-operation.

Summary.—Die-back in apples and pears is widespread in eastern and southern England ; twenty-seven cases in apples have been brought to the writer's notice from the counties of Norfolk, Suffolk, Essex, Hertfordshire, Kent and Devon, up to the end of 1944. In all of them there was marginal leaf scorch and in the large majority typical iron and manganese symptoms.

Analyses proved them to be low in potassium, iron and/or manganese. In six boron was low. In most of them iron was low, whereas in the past iron has been found high in amount but in an unavailable form.

The potassium deficiency is the result of wartime shortage of potassic manures.

The trace element deficiencies result from the naturally calcareous nature of the soils or from calcareous applications and low organic matter.

Preliminary experimental injections of the necessary nutrients in solid form have given encouraging indications and more extensive trials are being carried out in the hope of finding a rapid cure, otherwise large numbers of trees are likely to die before slow acting soil applications become effective.

References.

Bennett, J. P. (1931). "The treatment of lime-induced chlorosis with iron salts." *Univ. Calif. Agr. Exp. Sta. Circ.*, 321.

GOODALL, D. W. (1943). "Studies in diagnosis of mineral deficiency. I. The distribution of certain cations in apple foliage in early autumn." *J. Pomol.*, **20**, 136-43.
ROACH, W. A. and ROBERTS, W. O. (1945). "Further work on plant injection for diagnosis and curative purposes." *J. Pomol.*, **21**, 108-119.
WALLACE, T. (1943). "The Diagnosis of Mineral Deficiencies in plants." H.M. Stationery Office, London.
——— (1944). Supplement to above.

LEAF PAINTING AS A METHOD OF DIAGNOSIS OF MINERAL DEFICIENCY

By W. O. ROBERTS

SOME deficiencies in fruit trees, particularly cherry and plum, are not easy to diagnose by means of leaf injections as these leaves absorb nutrient solutions slowly. Painting of the leaf surface with a nutrient solution was therefore tried as a possible method for diagnosing the deficiency. The method also determines the most suitable concentration for a curative spray.

In a preliminary experiment on a chlorotic hydrangea plant the leaves were painted on both surfaces, and responses were obtained with 0·25, 0·5 and 1% ferrous sulphate with 0·1% wetter of the saponin type added. Damage was caused by higher concentrations.

In another experiment on peas growing in an area likely to be deficient of manganese the leaflets on one side of the last fully expanded leaf were painted, the remaining half on the other side of the midrib being left unpainted for comparison. Each treatment was done four times. The strengths of solutions used ranged from 0·025% to 5% $MnSO_4$ with 0·1% spreader, and when examined nine days later all the four leaves painted with 0·5% manganese sulphate were markedly darker green on the painted than on the untreated side.

Leaves on a cherry tree known to be deficient in manganese were painted with various concentrations (0·25%, 0·5%, 1%, 1·5% and 2%) of manganese sulphate solution, each being done in quadruplicate on two different occasions. It was found necessary to increase the amount of wetter to 0·2% because of the smooth oily surface of the cherry leaf. Good responses were obtained on all four sets of leaves painted with 0·25%, 0·5%, 1% manganese sulphate but the best response was with 0·5% on both occasions (Fig. 3). The response to 1·5% and 2% was less good than that to the lower concentrations. In this experiment several leaves of a spur were used as a unit, or, if comparable chlorotic spurs occurred close together one was used as control and all the leaves on the other were painted.

This method has already been used successfully for diagnosis of the cause of a serious trouble in cherries described elsewhere in this Report. (See p. 61.) The response to iron will be seen in Fig. 1, and that to zinc in Fig. 2. (See p. 68.)

The above results suggest that the method is worth further trial as a routine method of diagnosis especially for trees which do not absorb injected liquid satisfactorily.

Summary.—Deficiencies of trace elements have been diagnosed by painting the leaf surface with solution containing the elements.

An improvement in colour and general appearance was observed in one or two weeks.

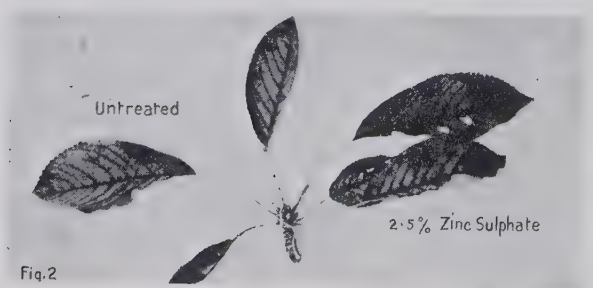
COMPARISON OF DIAGNOSIS OF MANGANESE DEFICIENCY IN MANGOLDS WITH EFFECTS OF CURATIVE SPRAYING

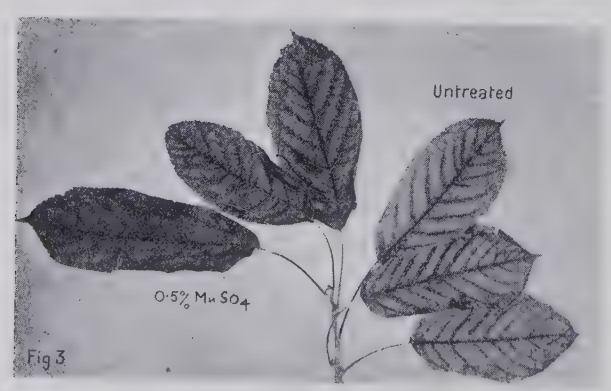
By W. A. ROACH and T. N. HOBLYN

THE occurrence of severe leaf symptoms on mangolds growing on the highly calcareous peat on the old lake bed at Bradbourne offered an opportunity of comparing diagnoses based on symptoms and on leaf injection with the results of curative spraying measured as crop yield.

Symptoms.—Dr. Wallace was good enough to examine the symptoms and diagnosed them as those of manganese deficiency.

Plan.—The mangold rows ran the whole length of this part of the lake bed. The plan of the experiment will be found in Fig. 1.





FIGS. 1, 2 and 3.

Results of painting cherry leaves with solutions of iron sulphate, zinc sulphate, and manganese sulphate.

(*See p. 67.*)

The experimental unit consisted of three rows of mangolds, each row approximately 200 yards long. Eight of these units were sprayed and an equal number left unsprayed for comparison. The A.B.B.A. arrangements of the plots were randomized.

Spraying.—Spraying with 1% $MnSO_4$ with spreader was done by members of the farm staff with a small portable machine such as is used in orchards. The spraying was done first on 11th July. As rain fell the same night the spraying was repeated on 14th July.

Harvesting.—Because of spray drift the two outer rows of each plot were rejected and yield estimates were confined to the central row only. From each central row two lengths of 100 yards each were marked out so that they formed two strips across the length of the lake bed. All the mangolds not wanted experimentally were first lifted and removed, then the experimental ones were lifted, put into boxes marked with the row and strip number, removed and weighed.

Results.—The results are shown graphically in Fig. 1. The two points representing the yields for each pair of sprayed rows are joined by a line, the mid-point of which represents their average yield. The vertical line joining the averages for corresponding sprayed and unsprayed pairs represents the effect of the spraying. It will be seen that seven of these are positive ; only one (represented by

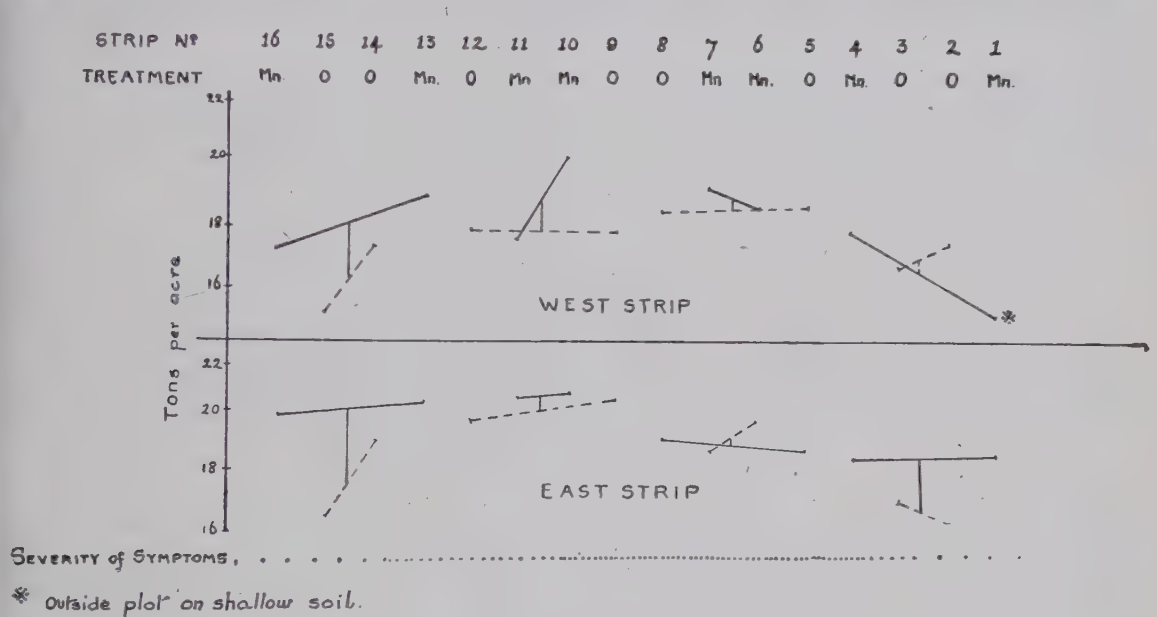

STRIP Nº 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
TREATMENT Mn. 0 0 Mn. 0 Mn Mn 0 0 Mn Mn. 0 Mn. 0 0 Mn.
Tons per acre
22
20
18
16
WEST STRIP
EAST STRIP
Severity of Symptoms
* Outside plot on shallow soil.

Fig. 1.
Comparison of yields of strips sprayed and not sprayed with manganese sulphate and intensity of symptoms.
Note : Severity of Symptoms indicated by spacing.

a dotted line) is negative. This exceptional result is probably explained by the fact that the outside manganese sprayed plot was on soil less than six inches deep and overlying the hard apparently impenetrable material.

Statistical Report.—It is a little difficult to express the results of this experiment in terms of means and standard errors, since the effect of the spraying differed so greatly in different parts of the lake bed.

The differences between manganese sprayed and unsprayed plots for the eight pairs of plots in pounds per 100 yards of row were :—

							N. <———		
W. Strip	—139*	+72	—4	+46	+164	—20	+111	+145	Mean +46·9
E. Strip	+134	+93	+57	—20	+19	+43	+81	+206	Mean +76·6
Both	—5	+165	+53	+26	+183	+23	+192	+351	Mean +123·5

* Outside sprayed plot on shallow soil.

Taking both plots together the Mean yields were :—

	Manganese	1356 lbs. per 200 ft. of row.
No	Manganese	1232 lbs. per 200 ft. of row.
	Difference	+123·5 lbs. S.E. 42·8 P=·05.

The yields per acre were :—

Manganese	22 tons (approx.).
No Manganese	20 tons (approx.).

The difference on the whole is therefore statistically significant, but the actual differences between adjacent sprayed and unsprayed plots varied considerably in different parts of the lake bed. On the whole, apart from one plot influenced by shallow soil and one plot in the middle of the W. strip, the effect was much greater on the outside than in the middle. This is especially marked in the East strip as shown by the actual plot yields :—

Manganese	661	659	729	677	792	781	766	742 lbs. per plot 100 ft.
No Manganese	527	566	672	697	773	738	685	536 lbs. per plot 100 ft.

Thus in the unsprayed plots the outside effect is marked, while the manganese sprayed plots are comparatively uniform. It seems evident that the deficiency had little effect on yield in the middle whereas it had a marked effect on the outside.

Yield, Symptoms and Effect of Spray.—The comparative intensity of the leaf symptoms is indicated by the spacing of dots along a line at the foot of Fig. 1. It will be seen that in each untreated row the yield is high in the middle, where the symptoms were most severe, and low at each end where symptoms were slight. The effect of the manganese spray, however, was greater at each end where the symptoms were slight, and small where the symptoms were severe.

Acknowledgement.—The spraying, lifting and weighing were done by members of the farm staff supervised by the foreman, Mr. Bates.

Summary.—Yield measurements were made on manganese sprayed and unsprayed strips of mangolds on areas exhibiting differing degrees of severity of leaf symptoms.

On the unsprayed plots the yield was highest where the symptoms were most severe.

The spraying produced the largest increase in crop on the mangolds exhibiting the least severe symptoms.

COMPARATIVE SUSCEPTIBILITIES OF CERTAIN HORTICULTURAL AND AGRICULTURAL PLANTS TO TRACE ELEMENT DEFICIENCIES

By R. J. GARNER and W. A. ROACH

A HIGHLY calcareous peat, derived in all probability from a lake bed, when used in 1943 as a cutting bed gave excellent rooting and growth that was excellent in some places, but not so good in others. Symptoms resembling those of mineral deficiency were observed and a few diagnostic injections gave suggestive results. In 1944 a total of thirteen different crops were grown, to determine both the possibilities of the area as a cutting bed and the range of their susceptibilities to trace element deficiences.

Site.—The area measures approximately 400 ft. from east to west and is about 85 ft. wide. It slopes gradually from west to east and is lower in the middle than at the north and south sides. This area has not been under water for many years, but the soil is of the same type as that in the recently drained part of the lake bed.

Crops.—The six fruit-nursery crops: Apple M1., Quince A, Myrobolan B, blackcurrant "Goliath," gooseberry "Careless" and willow *Salix vitellina* "*Goldenensis*" (the first two as rooted layers and the remainder as hardwood cuttings) were planted alternately with the five indicator plants : swede "John Bull", cauliflower "Autumn Giant", potato "Majestic", mangold "Red Intermediate" and oats "172", in eight blocks. Both the cuttings and indicator plants were in whole rows running the width of the area and the arrangement of the rows was at random. A few rows of peas were also sown and there was one row of Boysenberries.

Potatoes.—*Yield.*—The yield was good, averaging about 20 tons per acre over the whole area. The yield of each individual hill is shown in the diagram. The low yielding plants in the NE. corner were growing in shallow soil and those in the NW. corner were close to a beech tree. It will be seen that, if these plants just mentioned be excluded, the yield decreases steadily from west to east and in the eastern half from the sides to the middle.

Symptoms.—The intensity of necrotic spots on either side of the veins, characteristic of manganese deficiency, increased from W. to E. and in the eastern half from the sides to the middle.

Yields and Symptoms.—There was, therefore, a most satisfactory inverse relationship between yield and intensity of symptoms.

BRADBOURNE LAKE BED

POTATOES

YIELD OF INDIVIDUAL HILLS

AND

INTENSITY OF MANGANESE DEFICIENCY SYMPTOMS

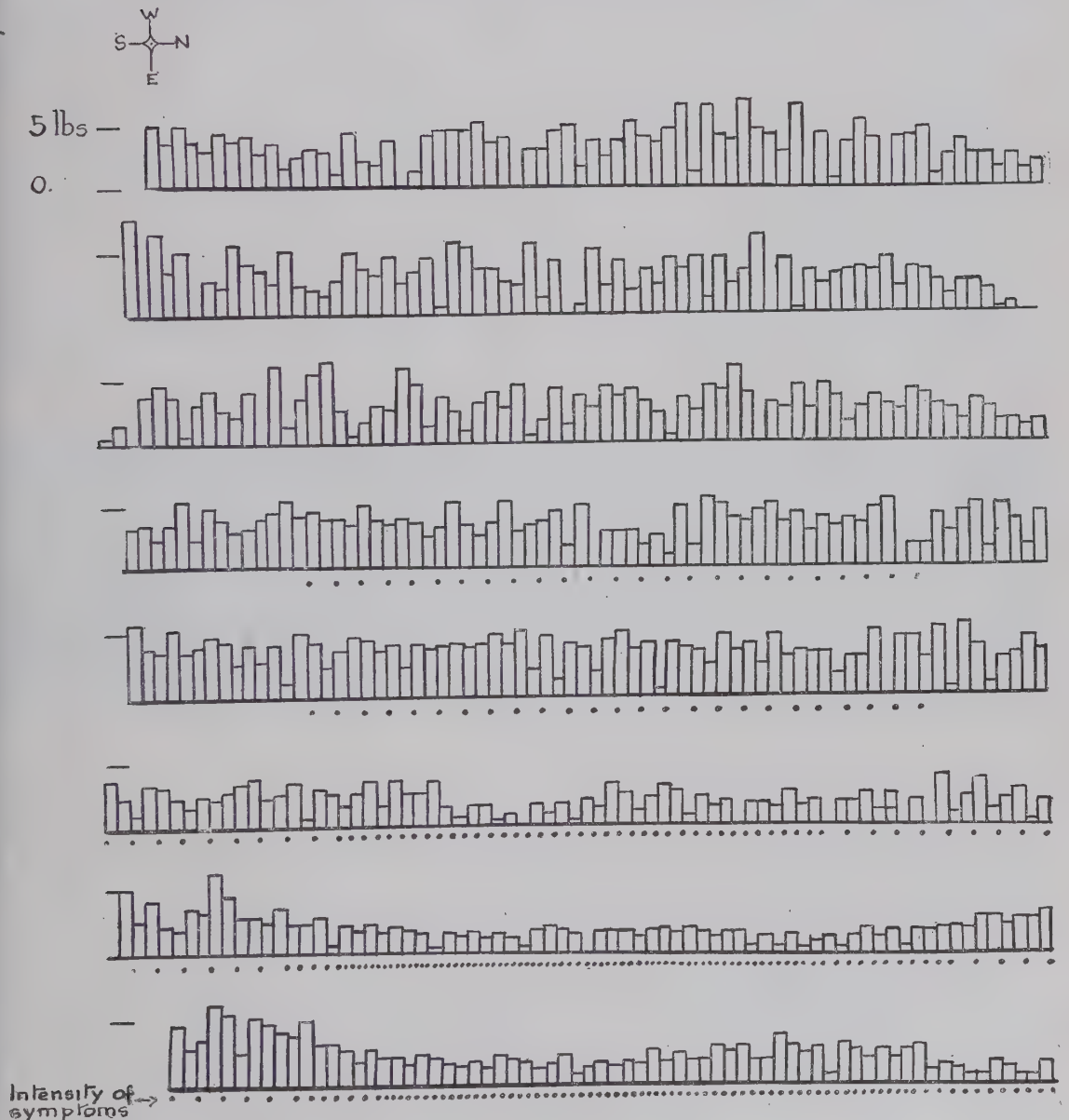


FIG. 1.

Quince A.—There were occasional symptoms of the manganese deficiency type and there was a just detectable tendency for these symptoms to increase and for growth to become slightly weaker from west to east and in the eastern half from the sides to the middle.

Willow.—The growth at the western end was excellent. The distribution of symptoms and growth were the same as for the potato. The willows at the eastern end responded markedly to injections of iron but not manganese, but the symptoms were identified by Professor Wallace as being of the manganese deficiency type.

Apple Rootstock M1.—All the rootstocks grew well and the growth of many was much above the average.

There were slight symptoms, diagnosed by Professor Wallace to be those of iron deficiency. The distribution of these was similar to that of manganese deficiency symptoms in the potatoes.

Blackcurrant.—Professor Wallace diagnosed symptoms of iron deficiency at the eastern end of the plot where growth was not so good as at the western end. At the western end the growth was much superior to that in nurseries on normal soil.

Myrobolan B.—Symptoms of manganese deficiency were general, their intensity increasing as in the potato. Vigour decreased slightly as the intensity of the symptoms increased.

Swedes.—Swedes made poor growth and were attacked by a "rot", the nature of which was not determined.

Cauliflower.—Healthy plants were produced and no deficiency symptoms were observed.

Experimental spraying with manganese sulphate led to no perceptible improvement in appearance.

Gooseberry.—Counting from the east, rows 1, 2, 6, 7 and 8 showed marginal scorch (potassium deficiency) but rows 3, 4 and 5 were almost perfect.

Mangolds.—The growth of these was similar to that of the main lot of mangolds described in another communication by Roach and Hoblyn (1945), p. 68.

Oats.—The seedlings early in their lives exhibited severe symptoms of manganese deficiency, which were confirmed by the results of spraying (see Fig. 2) and injection. Most of the unsprayed plants died before reaching half normal height. The intensity distribution of the symptoms was similar to that in the potatoes.

FIG. 2.
Oats unsprayed (u) and sprayed (s) with 1% manganese sulphate and spreader.

Barley.—Barley plants mixed with the oats exhibited the symptoms characteristic of manganese deficiency, but the barley was not affected nearly as severely as the oats.

Boysenberry.—*Symptoms.*—There was a chlorosis of medium severity. This was of the type characteristic of iron deficiency in a number of kinds of fruit trees. It occurred mainly on leaves at the tip of the shoot, a character also looked upon as characteristic of iron deficiency.

Effect of Spray.—A spraying test proved the deficiency to be that of manganese.

Peas.—Peas exhibited a slight chlorosis of the leaves and there was marsh spot on the cotyledons.

Conclusions.—The plants tested exhibited a wide range of susceptibility to trace element deficiency. The most striking difference was that between the potatoes and oats on the one hand and willows on the other. The potatoes and oats were affected severely by manganese deficiency and the willows severely by iron deficiency. This fact suggests caution in the use of indicator plants for predicting deficiencies in plants not exhibiting specific symptoms from a study of those that do exhibit specific symptoms.

The fact that the willow exhibited symptoms characteristic of manganese deficiency in fruit trees, but was proved to be deficient in iron but not manganese, and the fact that the Boysenberry

exhibited symptoms characteristic of iron deficiency in fruit trees, but was proved to be affected by manganese deficiency, suggests that it is unsafe to diagnose a deficiency in a new plant on the general type of symptom.

Summary.—Thirteen different kinds of plants were grown on a highly calcareous peat to study their relative susceptibility to trace element deficiencies.

They differed markedly in susceptibility both quantitatively and qualitatively.

Oats and peas were the most highly susceptible to manganese deficiency, and barley, potatoes and mangolds slightly less so.

Willows were highly susceptible to iron deficiency.

The symptoms shown by the willows were those looked on as typical of manganese deficiency in fruit trees.

Boysenberry showed symptoms looked on as characteristic of iron deficiency in fruit trees, but was proved to be affected by manganese deficiency.

There was an inverse relationship between severity of symptoms and crop in potatoes, oats, peas and willows.

PLANT PATHOLOGY

AN EXPERIMENT ON THE CONTROL OF CROWN GALL ON VEGETATIVELY RAISED APPLE ROOTSTOCKS

By H. WORMALD and R. J. GARNER

Crown gall has long been a cause of loss to nurserymen in many countries, particularly because of its frequent occurrence on young fruit trees. In this country observations and experiments indicate that this disease is not generally detrimental to orchard trees on vegetatively raised rootstocks, but galls on nursery trees do constitute a bar to their disposal and efforts should be made to prevent their development.

In America, where "bench-grafting" is largely practised, crown galls and also non-infectious wound-overgrowths, often arise at the place of grafting, and wrapping the unions after grafting is recommended (Riker and Keitt, 1926).

In Europe the galls on young fruit trees develop mostly either at the cut or ruptured surfaces at the base of the vegetatively raised stocks, or on the cut ends of roots of seedling trees that have been root-pruned when planted out, and attempts at control have aimed at protecting the exposed tissues. Some measure of control was obtained by Wormald and Grubb (1922) by painting the exposed surfaces with Stockholm tar or grafting wax. Oppenheim (1926) used an organic mercurial preparation sold under the trade name of Uspulun (containing hydroxymercurichlorophenol) for treating the soil and for the preparation of a soil and disinfectant mixture for coating the lower ends of young trees; the soil treatment proved ineffective against crown gall but it promoted vigour and stimulated root development, while some control of crown gall was obtained by covering the root systems with the preparation. Since that time Uspulun and other organic mercurials have been frequently recommended on the Continent for treating nursery trees (Husz, 1930; Boumann, 1933; Stapp, 1938; Stapp and Müller, 1938; Hornbostel, 1939). Boumann (1933) using Uspulun, found that soil treatment gave inconclusive results and was not to be recommended, but that immersing the roots in a soil and Uspulun mixture not only gave satisfactory results against crown gall but that, at the end of the experiment, there were more surviving trees in the treated than in the untreated series.

In 1935, experiments were started at East Malling to test the value of mercurial dressings as protection against crown gall of apple rootstocks raised by layering or stooling. In a preliminary trial one of these preparations was Uspulun, and this gave promising results. In a further trial of Uspulun started in 1936, although there were fewer galls on the treated than on the untreated, the rootstocks producing galls were so few (only 2·1 per cent. on control plants) that the results were considered to be inconclusive.

Another experiment, started in 1938, confirmed previous observations and, as it was on a fairly large scale, the results are now presented, particularly as wartime conditions have prevented a repetition, and it is uncertain when further trials on similar lines can be made at this Station.

The root systems and stem bases of rootstocks Malling II (as removed from the layer rows) were immersed in a mixture of a solution of Uspulun and soil forming a wet paste or "slurry", and the young rootstocks were then planted out towards the end of March, 1938. This was rather late in the season

for planting, and as the succeeding summer was relatively dry the number of dead rootstocks at the time of lifting was abnormally high. The " slurries " used were :

A. (½%) 4 oz. Uspulun in 1½ gallons water +3½ gallons soil.
B. (¼%) 2 oz. Uspulun " " " " "
C. (control). No Uspulun " " " " "

These proportions were found to form pastes of a consistency suitable for dipping the roots.

Four hundred rootstocks were subjected to each treatment and then planted in 8 plots, each divided into 3 sub-plots (randomized) for the three treatments ; each sub-plot thus received 50 rootstocks, 1,200 in all.

The rootstocks were lifted in May, 1939, and the numbers recorded for the rootstocks alive, those with galls, and those free from galls.

RESULTS OF USPULUN EXPERIMENT.

400 rootstocks in each of the three series.

Treatment.	Number alive.	Percentage alive.	No. of living rootstocks without galls.	Percentage of living rootstocks without galls.	Percentage of clean rootstocks out of total treated.
A (½%) ..	189	47·3	99	52·4	24·8
B (¼%) ..	173	43·3	84	48·6	21·0
C (Control) ..	91	22·8	16	17·6	4·0

The figures were examined statistically ; between A and B there was no significant difference but both were significantly different from C.

The results show that on the treated plots living rootstocks were about twice, gall-free living rootstocks about three times, and saleable rootstocks five to six times, as many as those on the control plots.

As stated above the conditions of the experiment were exceptional, and this was a factor accounting for the high percentage of living rootstocks and of saleable rootstocks from the treated plots when compared with those of untreated plots. Under favourable soil conditions there would have been a better " stand " in all plots, and the percentage of saleable rootstocks from the untreated plots would have been higher, probably approximating to that shown in column 4 of the table.

It is evident that Uspulun, at the concentration used, was not only unharmful to the rootstocks, but that it stimulated root development. Only about half the treated rootstocks were free from galls, however, and the preparation could probably be used at a higher concentration with advantage ; in any future trials the mercurial compound should be used at greater strength.

Summary.—A mixture of soil, Uspulun and water used as a paste (slurry) into which the root systems of apple rootstocks were immersed just before planting gave some control of crown gall and resulted in a better stand.

REFERENCES.

BOUMANN, ADRIANA M. (1933). " Bestrijding van bacterieele wortelknobbels bij appel en peer." *Tijdschr. Plziekt.*, **39**, 217-24.

HORNBOSTEL, W. (1939). " Versuche über Wurzelkropfbekampfung." *Z. Pfl Krankh.*, **49**, 1-11.

HUSZ, B. (1930). " Schützt die Beize die Obstbäume gegen den Wurzelkropf." *Kertesz. Labok*, **44**, 96-99.

OPPENHEIM, H. R. (1926). " Verhutung und Heilung krebsartiger Pflanzengeschwulst." *Angew. Bot.*, **8**, 8-29.

RIKER, A. J. and KEITT, G. W. (1926). " Studies of crown gall and wound overgrowth on apple nursery stock." *Phytopathology*, **16**, 765-808.

STAPP, C. (1938). " Der Wurzelkropf oder Bakterienkrebs der Obstbäume und seine Bekämpfung." *Biol. Reichans. Land u. Forst.* Flugbl., **78**, 1-7.

STAPP, C. and MULLER, H. unter Mitwirkung von DAME, F. (1938). " Der Pflanzenkrebs und sein Erreger *Pseudomonas tumefaciens*. VII. Mitteilung. Untersuchung über die Möglichkeit einer wirksamer Bekampfung an Kernobstgehölzen." *Zbl. Bakt.* II., **99**, 210-76.

WORMALD, H. and GRUBB, N. H. (1922). " Notes on the control of nursery stock against crown-gall." *Gdnrs' Chron.*, **71**, 198.

A BLACK APPLE ROT CAUSED BY *MONILIA CINEREA**

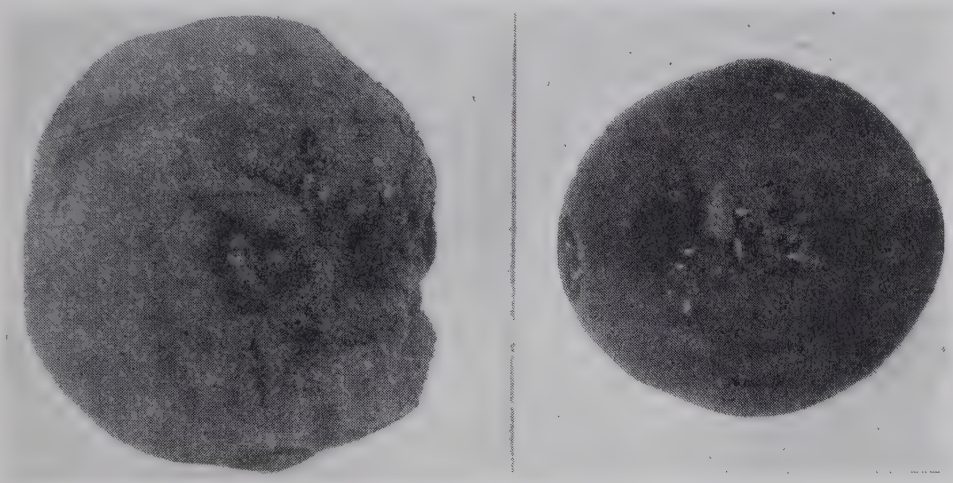
By H. WORMALD

THE rot known as Black Apple is of frequent occurrence on apples in storage. It is usually a result of infection by the Brown Rot fungus *Monilia fructigena* (*Sclerotinia fructigena*), for isolations from such apples by workers in this country and on the Continent have yielded *M. fructigena*. In America a similar Black Apple rot is caused by the closely related fungus *Sclerotinia fructicola*.

The first record of apples turning black when infected with a brown rot fungus appears to be that by Worthington G. Smith, in *The Gardeners' Chronicle*, 11th July, 1885 (Vol. XXIV, new series, page 42), where it is stated, with reference to *Oidium fructigenum* (a name used at that time for *Monilia fructigena*), that " The fungus has, in some instances, the power of changing the skin of the Apple to a jet-black colour."

In Brown Rot as seen on apples in the open the concentric rings of the yellowish fructifications of *Monilia fructigena* are conspicuous every year as the fruit approaches maturity. On apples in the store, however, the Monilia fructifications are absent, or very few and then usually represented by tufts of barren hyphae, and the skin of the affected apples often turns dark brown, then black. Unlike the infected apples on the tree, which rapidly shrink and become shrivelled " mummies ", these black apples assume a rubbery consistency and shrink very slowly.

The other Brown Rot fungus in Britain, *Monilia cinerea* (*Sclerotinia laxa*) is common on the stone-fruits, and causes Blossom Wilt of various kinds of fruit trees (apple, pear, plum, cherry, peach and



Bramley's Seedling apples, five-and-a-half weeks after inoculation with *Monilia cinerea*.
Left: exposed to light. Right: kept in the dark.

apricot) and of certain ornamental shrubs of the family Rosaceae. It rarely infects apple fruit, though it has occasionally been found on apples in storage, causing a brown rot.

In August, 1944, the writer received an apparently typical Black Apple,† but it was so black and shiny, and the blackening had appeared so early in the season that it roused a suspicion that the cause might be some fungus other than *Monilia fructigena*. The skin was quite smooth and no fungal fructifications were present. It was therefore impossible to identify the fungus directly, so small pieces of the fruit, taken from beneath the skin, were placed on agar culture plates. These gave rise to cultures unlike those of *M. fructigena* but they resembled those of *M. cinerea*.

As it did not produce spores on these plates the fungus was inoculated into apples, pears, and damsons, which were then exposed to light to induce the development of fructifications for confirmation of its identity. All the fruits became rapidly infected and within five days $\frac{1}{4}$ to $\frac{1}{2}$ of the surface of the apples and pears was discoloured and bore a few of the grey cushion-like fructifications typical of *Monilia cinerea*, while the damsons were discoloured over their whole surface and bore many such fructifications.

* Reprinted from *The Gardeners' Chronicle*, **117**, 115, 17th March, 1945, by permission of the Editor.

† The writer is indebted to Mr. G. C. Johnson, Horticultural Officer for East Sussex, for sending him this specimen.

The fungus was then inoculated into apples to ascertain the effect of light on the development of fructifications and on the production of the black colour. Four apples of each of two varieties, Bramley's Seedling and King Edward VII, were inoculated ; two of each variety were then placed on a bench under a window, the other two in a dark cupboard. All became infected, and in three weeks were discoloured over their whole surface. The apples in the light then showed a brown rot with no blackening, and all bore many grey pustules of *Monilia cinerea*, which were more numerous on the King Edward than on Bramley's Seedling. Of those in the dark the Bramley's Seedling bore a few white tufts of hyphae and were dark brown, almost black, on the inoculated side ; the King Edwards bore many white tufts of hyphae and were brown without any blackening.

The illustration is of two of the Bramley's Seedling apples 5½ weeks after inoculation ; *a*, one of those exposed to light, shows a brown rot, is somewhat shrunken, and bears many fructifications of *Monilia cinerea ; b*, kept in the dark, has turned quite black, is hardly shrunken, and bears a few white tufts of hyphae only.

Only the two Bramley's Seedling in the dark turned completely black and after two months still remained almost smooth with but very little shrinking. All the others were still brown and much shrunken and wrinkled, particularly the King Edwards in the light ; these had produced fructifications most freely, a factor associated with their rapid shrinking.

Experiment thus shows that with this fungus the Black Apple condition was induced on Bramley's Seedling kept in the dark, but not on King Edward even in the dark, and that few, if any, fructifications developed in darkness. The blackening thus depends on storage in darkness and on the variety of apple.

It thus appears that not only *Monilia fructigena* but also *M. cinerea* may cause apples to rot and turn black after they are picked and stored. Both fungi attack ripening fruit in the orchard and produce myriads of spores, and it must frequently happen that fruit with infection spots, too small to be easily detected, are taken into the store. This infection will extend until the whole fruit becomes affected and turns brown or eventually, in some varieties, black.

Summary.—It is shown that the Black Apple condition of stored apples may be brought about not only by *Monilia fructigena*, the usual cause, but also by *M. cinerea*.

STRAWBERRY LEAF BLOTCH FUNGUS*

By H. WORMALD

THE first account of the occurrence in Britain of Leaf Blotch of strawberries was published in *The Gardeners' Chronicle*, 15th November, 1941, the year when the disease appeared in seven places in Kent. The fungus found on the affected leaves was referred to as *Phyllosticta grandimaculans*, the name given to it by Bubák and Krieger in 1912 (*Ann. mycol. Berl.*, X, 46). In 1908, however, Laibach had described what is undoubtedly the same fungus and had named it *Zythia Fragariae* (*Arb. biol. Anst., Berl.*, VI, 79).

The fungus associated with Strawberry Leaf Blotch in Britain has been examined by several mycologists, including Mr. T. Petch, an authority on such forms (*Trans. Brit. mycol. Soc.*, XXVI (1943), 70), and it is generally agreed that it is a Zythia rather than a Phyllosticta—from the colour of the fructifications which are brownish (pale and yellowish in culture), and not black as in a typical Phyllosticta, and from the consistency of the fruit body which is waxy, not coriaceous or carbonaceous. The conidial stage of the Strawberry Leaf Blotch fungus should be referred to, therefore, as *Zythia Fragariae* Laibach.

In Britain the Leaf Blotch appears to have been first observed by L. Ogilvie in November, 1931, on seedling strawberry plants at Long Ashton, Somerset, though a fungus believed to be identical with *Zythia Fragariae* had been found on strawberry fruits, received at the Plant Pathological Laboratory at Harpenden from Hereford, in July that year. The Leaf Blotch was next found by C. J. Hickman, at Westerham, Kent, in 1939. These observations are recorded in "Diseases of Crop Plants, 1933-1942", by W. C. Moore, *Bull.* 126, *Ministry of Agriculture* (1944), p. 70.

Mr. Hickman has informed me that in 1942 he again found Leaf Blotch, this time in Worcestershire, on the variety Huxley, an adjoining variety Western Queen being unaffected.

In July this year (1944) Royal Sovereign strawberry leaves bearing the Zythia were brought to me from Carnarvonshire, North Wales, and more recently, September, I received leaves bearing the fungus from Hampshire and Norfolk. Up to the present, then, Strawberry Leaf Blotch has occurred in six counties of England and Wales.

When the disease appeared in 1941 the fungus was grown in pure cultures with the object of

* Reprinted from *The Gardeners' Chronicle*, **116**, 160-61, 28th October, 1944, by permission of the Editor.

fisting its parasitism, and the Zythia stage appeared regularly in the culture dishes and tubes. This was the only form of fructification that developed until March, 1944, when black spherical perithecia with long necks were found in one of the culture tubes. The ascospores were small (about 10-12 by 2μ), mostly with four guttules or oil-drops, but some of them were two-celled, and the fungus proved to be a Gnomonia.

At first it was thought that this perithecial (perfect) form might be a contaminant, but later both forms developed in cultures derived from conidia, unripe asci, and ascospores, respectively. Both forms have this year been found together, on strawberry leaves that became infected after inoculation from pure cultures, and also on naturally infected leaves obtained direct from a garden at Brottiscliffe, Kent.

When growing in the leaf the spherical portion of the fructification is embedded in the leaf tissues and the long neck projects like a dark brown or black bristle, just visible to the naked eye and easily seen with a lens. These necks are easily distinguishable from the longer, almost colourless hairs of the leaf.

The Royal Sovereign leaves received from Carnarvonshire this year were severely affected by Powdery Mildew and the common leaf spot fungus *Mycosphaerella Fragariae*, but on some of the leaves there were pycnidia containing rod-shaped biguttulate spores similar to those of *Zythia Fragariae*. The typical symptoms of Leaf Blotch were masked by the mildew and the leaf spots, so for confirmation of its identity the fungus was isolated and inoculated into strawberry leaves. In culture it developed both stages of the fungus, and when inoculated into strawberry leaves it readily caused lesions on which the Zythia fructifications appeared. Thus the presence of the Leaf Blotch fungus in North Wales was confirmed.

The name of the perfect stage has not yet been determined with certainty but it comes very near to, and is possibly identical with *Gnomonia herbicola* (described and named by Miss Annie Lorraine Smith), found in Derbyshire in 1908 and 1909 at the base of living stems of the Greater Willow Herb, *Epilobium hirsutum* (*Trans. Brit. mycol. Soc.*, 3 (1910), 221). This raises the question as to whether the Strawberry Leaf Blotch fungus has hosts other than the strawberry and whether wild plants may serve as sources of infection. This question cannot be answered until further observations and experiments are made.

In the meantime, however, it may be stated that on strawberry plants the fungus is definitely parasitic, for positive results have been obtained on strawberry leaves (on leaves kept in moist chambers and on leaves of plants in pots under laboratory conditions) with inoculations from pure cultures; both stages of the fungus appeared on infected leaves, first the Zythia stage, later the Gnomonia, the latter on the petioles. It has also been successfully inoculated into leaves of cinquefoil (*Potentilla reptans*), the Zythia stage developing on them within ten days, and on leaves of the wild strawberry, *Fragaria vesca*.

In order that growers of strawberries may be able to recognize this disease it may not be out of place to outline the symptoms as given in the former article. While still small the spots are almost indistinguishable from those of the common Leaf Spot caused by *Mycosphaerella Fragariae* but they never develop the white mould which is the Ramularia stage of the Leaf Spot fungus. As the blotches extend they may become an inch or more across or they may eventually involve the whole leaf. These larger blotches have usually a small pale brown centre, then a broad brown zone bordered by a narrow, dark purplish zone, and outside this an ill-defined yellowish zone.

The disease has been found mostly on the variety Royal Sovereign, but it has occurred on Huxley's Giant also. Growers who see a strawberry leaf blotch as described are asked to send specimens to the writer as further information is required regarding the distribution of the disease and of the damage it causes.

Summary.—The imperfect (conidial) stage of the Strawberry Leaf Blotch fungus is now referred to *Zythia Fragariae* Laibach. The perfect (perithecial) stage produced in cultures and on infected strawberry leaves is a Gnomonia. The Leaf Blotch symptoms are outlined so that growers may recognize the disease.

ENTOMOLOGY

NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1944

By A. M. MASSEE

1. Plum Weevil (*Magdalis ruficornis* L.) is very closely allied to the Pear Weevil, *Magdalis barbicornis* Lt., a species which attacks cultivated pear in the Channel Islands, and has occurred in abundance on medlars in Cambridgeshire.

The Plum Weevil was sent to East Malling from Ivanhoe, Bucks, where it was noted boring into

the bark of plum shoots just below the buds, causing them to dry up and fall out. The grub stage of the weevil causes this kind of injury. It lives under the bark in a small cavity that is hollowed out for the purpose.

These cavities or " larval chambers " are unlike those of many true wood-boring beetles, because they are isolated, and the grubs do not tunnel in many directions under the bark. The grub remains in its cavity all the winter, the adult weevil emerging the following spring.

The adult weevil is dull black and is from 2 to 3 mm. in length. The adult feeds on the under-surface of plum leaves in May and June. It is found on a large variety of trees and shrubs in addition to the plum.

The main stems and older wood seem to be attacked in preference to the one- and two-year-old growths.

Similar infestations have been noted in neglected orchards in the East Malling district, but the damage is not regarded as serious. The Plum Magdalis is the most common species of the genus, and it is generally distributed throughout the south-eastern part of England.

2. Heteromerus Beetle on Plum (*Mordella fasciata* F.). The very local and uncommon Mordellid beetle, *Mordella fasciata* F. was found infesting the trunks of old Victoria plum trees growing on a small holding at Wateringbury, Kent.

The grub stage of the beetle makes cylindrical borings, $\frac{1}{8}$ in. in diameter, in the trunks and main branches, and these galleries extend in all directions. The trees examined at Wateringbury were literally riddled with the tunnels of this beetle, and in some instances the damage was very considerable.

The adult beetles emerged during the second and third weeks of May. The beetle flies very readily on warm, sunny days, and it has the power of leaping strongly developed. It may be seen resting on the flowers of Umbellifers during the daytime.

The adult is black, with a variable band before and behind middle of wingcases. The pubescence is grey or yellowish-grey. The feelers are dark with the base red. The legs are black. Length 5-7 mm.

An undescribed Hymenopterous parasite was observed parasitizing the grubs of the beetle, and a number of specimens have been presented to the British Museum of Natural History.

3. Apple Fruit Rhynchites (*Rhynchites aequatus* L.). Although the Apple Fruit Rhynchites occurs more commonly on apple than on plum, it proved to be very common on the latter fruit in the spring months, and it caused considerable damage to the fruitlets of several varieties of plum in the East Malling and East Farleigh districts of Kent.

It occurred most commonly in mixed orchards of apple and plum, more particularly in the orchards where the apple crop had been destroyed by the severe spring frosts.

The fruitlets of Czar plum were badly damaged at East Malling at the end of May. The weevils probe their rostums into the flesh of the fruitlets, making a regular, cylindrical hole, which varies in depth from just piercing the surface up to $\frac{1}{4}$ in. deep. A number of these punctures occur on a single fruit, and they tend to gum and distort the fruits as they develop.

The weevil occasionally lays an egg at the base of the hole, but most of the holes examined were empty. These borings are not made to any pattern, but are scattered about at random on any part of the fruit surface.

The attacks at East Farleigh were similar to those noted at East Malling, but the damage continued later in the season.

It is curious that this weevil should associate itself with cultivated fruits, since its natural host plant is the hawthorn, which grows abundantly in most hedgerows throughout the fruitgrowing areas. The weevil undergoes its transformations within the fruits of the hawthorn and this may account for its transference to cultivated fruits which belong to the same natural order of plants as the hawthorn, in seasons when haws are very scarce.

4. Flea Beetle on Apple (*Aphthona euphorbiae* Sk.). It is of considerable interest to record a species of Flea Beetle occurring on apple trees in Essex.

The species *Aphthona euphorbiae* Sk., which does not possess an English name, is regarded as a local species in this country, but it is sometimes common where it occurs. It usually frequents marshy situations and may be caught by sweeping low plants. Its natural host plants are *Linum usitatissimum* L., *Euphorbia* spp., and *Beta vulgaris* L.

The species was noted in considerable numbers in June feeding on the upper surface of apple foliage, but the injury caused by it was considered negligible.

It appears to have a wide distribution in Essex where it has been noted on apples at Colchester, Danbury, Great Braxted, Pilgrim's Hatch, near Brentwood, and at Writtle.

This appears to be the first record of a Flea Beetle occuring on top fruit, but a number of species are known to feed upon soft fruits and hops.

Aphthona euphorbiae Sk. is oblong oval, upper surface aeneous-green or bluish, underside black

tennae fuscus, testaceous towards base. It may be recognized from the other seven species of the nus found in this country by its finely punctuated thorax. The thorax of all other British species mpunctuate. It is 1½-2 mm. in length.

5. Heteromerus Beetle infesting Plum (*Rhinosimus planirostris* F.) occurred in profusion some old plum trees in a derelict orchard at Pilgrim's Hatch, near Brentwood, Essex, in July, 44. The beetles were readily captured by tapping the branches over a beating tray. A closer amination showed these beetles were breeding in the dead stems and branches, while a number of ults were found in cracks and under loose bark.

This insect has not been noted on healthy trees, and its presence in neglected orchards is unusual.

The Scolytid wood-boring beetle *Eccoptogaster rugulosus* Rz. was also present in the same orchard, here it was noted infecting shoots and spurs of both apple and pear. The presence of this insect an orchard can be detected very readily because the infested stems are usually " worked " by small ds, which feed on the beetle in its various stages, and the damage caused by the birds removing e outer layers of the shoots while searching for the larvae stands out very conspicuously.

6. The Clay Coloured Weevil (*Otiorrhynchus singularis* L.). The Clay Coloured Weevil has en referred to in these notes on five previous occasions, where its persistent attack of newly grafted ees, of currant, raspberry and young hop sets has been described.

A very serious infestation was noted in October, at Ardleigh, Essex, where the adults of this sect had completely devastated an acre of Seabrook's Black during the course of the summer.

These black currants were planted in the winter of 1943-4, and grew normally in the spring, ntil the Clay Coloured Weevil started nibbling the tips of the shoots at the end of May. The attack oved an unusual one, since the infestations continued at intervals until the latter part of October. his kind of injury rarely continues after the middle of June. A number of bushes were girdled as on as new growth was produced, causing the plants to remain dwarfed throughout the season. thorough spraying with lead arsenate checked the infestation for a short period, but later on it oved to be as severe as previously. By the end of the season it was estimated that an acre of ants had been destroyed and would have to be replaced. Probably the very dry weather prevailing ntil the middle of August prevented the bushes growing away from the infestations.

7. Ground Beetle eating Stored Apples (*Laemostemus terricola* L.).—Although certain species ground beetles are recognized strawberry pests, it is unusual for this family of beetles to feed upon ored apples. It is therefore of considerable interest to record *Laemostemus terricola* L. feeding on ne flesh of apples kept in dry storage in a cellar of a house at Holt Wood, Aylesford, Kent ; the amaged apples were noted in October, and several of the beetles were found to be the culprits. Two arieties of apple, Cox and Sunset, were chiefly affected. The beetles gnawed long grooves frequently quarter of an inch deep out of the fruit surface. This type of fruit injury is very serious since the uits start to rot in a few days, and must be constantly looked over for damage.

This ground beetle is widely distributed throughout the British Isles and it occurs commonly n cellars and outhouses ; it also frequents sandpits and open country where it is found under leaves nd stones.

It is a large insect measuring up to ¾-inch in length. It is elongate and bluish-black in colour ith long legs and antennae. In fact it is typical of the black beetles one sees running about in uthouses and woods.

8. Northern Winter Moth (*Operophtera boreata* Hübn.). Contrary to its name the Northern Vinter Moth has a wide distribution in the south-east of England, and is fairly plentiful in some easons. During the past three years it has been noted in some numbers in the East Malling district, uring a search for the wingless females of the common Winter Moth, which have been collected for xperimental purposes.

It is noteworthy that the wingless females of the Northern Winter Moth should occur in fair umbers on the trunks of apple, plum and cherry trees since the larval stage of this species is regarded s a birch feeder, upon which it may be found in May and June.

It is evident that the caterpillar will feed upon the foliage of apple and plum also, for the conpicuous caterpillar may be found on these trees at the end of April and May.

While it is not regarded as an economic insect, it is just another addition to the many insects hich infest fruit trees in the spring months.

9. Codling Moth. (*Cydia pomonella* L.).—Although the Codling Moth must be regarded as ne of the major pests of the apple, and the fact that its life-cycle and methods of control are well-nown, it is timely to refer to this insect once again because of its unusual behaviour in 1944, probably wing to the abnormal climatic conditions prevailing throughout the season.

The adults were observed on the wing very early in the season. Moths were seen flying at Harpenen, Herts., and at East Malling, Kent, at the end of April. The moths usually start to emerge during ne second week of June. Owing to the unsettled weather the moths emerged over a long period,

and there did not appear to be a peak period at the latter part of June, which is usual in Kent. Instead the moths were noticed in the orchards until the end of July.

Under these circumstances it proved difficult to time the spray application correctly. Many growers applied a lead arsenate spray (without lime-sulphur) early in June and obtained adequate control. Other growers, however, found that one early application only was not sufficient, and a second spray was applied in the middle of July. This latter application is the time recommended for Codling control in the north-west of England.

Some interesting observations were made in an apple plantation at East Malling, where the crop had been practically destroyed by the very severe May frosts. On 5th June, moths were noted on the wing on some Lane's Prince Albert trees, and it was obvious they were searching for the apple fruitlets for oviposition purposes. Two moths were seen laying their eggs on the upper surface of the leaves. A careful search followed and it was found that a number of eggs had been deposited on the foliage, and the few fruitlets which survived had one or more eggs laid on them.

There was no evidence of a second brood, but in a season when some of the moths were on the wing so early in the year, it is reasonable to think that a partial second generation did occur.

The subsidiary control measure of trapping the fully grown Codling Moth larvae in sacking or corrugated cardboard bands should be mentioned, and cannot be too strongly recommended on trees where the bark is smooth. Large numbers of larvae are caught when the bands are in position by the end of June. They should not be removed until the latter part of October.

It is not economic to put sacking traps on old trees with an abundance of loose bark, cracks and crevices, since on these trees the larvae find ample shelter without seeking the shelter of the sack bands.

10. Black-bodied Sawfly (*Pristiphora pallipes* Lep.). A number of larvae of this sawfly were sent to East Malling from a gooseberry plantation at Newbury, Berks., on 26th June. The larvae pupated at the end of the month, and adults started to emerge on 5th July in the laboratory.

The Black-bodied Sawfly is frequently found in association with the common gooseberry sawfly, but usually it is not nearly so troublesome. Although the Black-bodied Sawfly has a wide distribution, reports concerning its attacks on gooseberry usually come from the Midlands and seldom from the south-east of England.

The infestation at Newbury caused considerable damage, and defoliated many of the bushes.

The adult female is black, smooth and shiny ; the body is broad and stout ; the wings are transparent and iridescent.

There are four broods in a season. The first three broods make their cocoons in the curled leaves, while the fourth brood goes down into the soil to a depth of two to three inches. The adults emerge the following spring.

The Black-bodied Sawfly is easily controlled by means of a lead arsenate or derris spray. The secret of success is to apply the spray directly the larvae of the first generation are noted, usually towards the end of April or early May.

The injury caused by this and other species of gooseberry sawflies should be anticipated early in the season, otherwise the bushes may be partially defoliated before the attack is noted.

11. Nut Leaf Sawfly (*Croesus septentrionalis* L.). The second brood larvae of the Nut Leaf Sawfly were noted in considerable numbers feeding on the foliage of some Cob Nut trees growing in a plat in the Borough Green district of Kent. Specimens were also sent in from a private garden in the same village. Some of the larvae brought back to the laboratory were reared successfully in April, 1944.

The larvae occurred in batches of eight or nine, and were feeding in a row on the edge of the leaf. They are very ravenous feeders and frequently defoliate a whole bough. The larvae protect themselves against attacks by parasites by holding on to the leaf by means of their first three pairs of legs, the body being turned and waved about in all directions and frequently swinging over the head. This measure of protection is not entirely satisfactory, however, since no less than twelve different species of parasites have been recorded parasitizing the larvae.

The adult sawfly appears in the latter part of April and May and lays her eggs in small incisions in the veins of leaves. The mature caterpillar falls to the ground, and the pupal stage occurs in the soil. It is contained in a brown, elongated cocoon. The second brood occurs in September. It overwinters as a larva in the soil, and pupation takes place the following spring.

A lead arsenate spray, as recommended against the Nut Weevil, is very effective against this sawfly, should it occur in sufficient numbers to warrant control measures, which fortunately are seldom necessary.

12. Pear and Cherry Slugworms (*Caliroa limacina* Retz.). Attempts to rear the Pear and Cherry Sawfly in the laboratory have been made many times during the past twenty years, but each effort has failed until the present season, when a number of adults emerged in the breeding cage in July.

Larvae of the second generation, found in September feeding on pear leaves, were confined in a cage containing two inches of peat. When fully fed, the larvae buried themselves in the peat and remained there in hibernation during the winter months. The pupal stage was reached in the spring, and the adults emerged in July. The secret of rearing these insects in captivity seems to depend upon the way they are cared for during their hibernation period. Once they go down into the peat it is essential to keep them fairly dry, just moistening the surface of the peat about once every six weeks. During the spring months it is advisable to damp the peat once each week with tap water kept at laboratory temperature. By this means most of the larvae placed in the cage in September emerged as adults the following season.

The adult sawfly is black and shiny. The lower part of the forelegs is shiny, while that of the middle pair is fuscous. Length up to $\frac{1}{3}$ inch.

It is of interest to recall that the late Professor F. V. Theobald, of Wye, told the writer that he had never succeeded in rearing the Pear and Cherry Slugworm, although he made many attempts.

13. Plum Leaf Sawfly (*Priophorus pallipes* Lep.). An interesting example of the Plum Leaf Sawfly defoliating young plums in an orchard at Maidstone was noted in August.

Although this sawfly is generally distributed in England, it is not often found feeding on cultivated trees, and it has been noted only once before by the writer. In addition to plum, its host plants include pear, cherry, bullace, sloe, hawthorn, rose, bramble and birch.

The young caterpillars are pale greyish-green with a reddish tinge. Later on they are greyish-green, with sides and apical legs white. The head is frequently pale, dull, orange-brown, with yellow spots and a prominent black mark. The head of the mature caterpillar may be deep orange or dusky black.

The caterpillars when feeding make holes at random on the leaf surface. When at rest they remain motionless characteristically coiled up on the undersurface of the leaves. When fully fed they fall to the ground and the chrysalis is formed in a cocoon in the soil. There are two broods in a season, the first occurring in May and the second in August. The second brood overwinters as a caterpillar in a cocoon in the soil.

The fully fed caterpillars sent to the laboratory early in August, reached the adult stage in September.

The adult is black; the thorax shiny with greyish down, and two white spots. The legs are white with the tips black. The colour of the body varies. It is usually black, but may be testaceous with a pale yellowish tinge. Some of the Maidstone specimens proved to belong to this variety.

This insect is not regarded as an important economic species, but the second brood is frequently noted by growers and plum pickers.

14. Pear Sucker (*Psyllia simulans* För.) commonly occurs locally in the Maidstone district on unsprayed pear trees growing in the open and on walls. It hibernates in the adult state on the trees, and can be obtained by tapping the branches over a beating tray during the winter months. It is also common on some unsprayed pears growing at the Research Station.

The immature forms, like those of the familiar Apple Sucker, attack the blossom buds and flowers, and eventually the petals turn brown and sticky.

At present this species is not common enough to be regarded as a pest, but it may be noted that a closely allied species of America is an important enemy of the pear in some States.

Another species of pear sucker (*Psyllia pyricola* För.) occurs in this country; it was noted in considerable numbers at Belvedere, near Dartford, Kent, in 1928 on several pear varieties growing in a commercial orchard, and it was referred to in these notes in 1941.

15. Predaceous Hemipteron on Apple and Plum (*Loricula elegantula* Baer.). In general terms it may be said that the most important fruit pests occur wherever fruit is grown in this country. This is not true of some of the unimportant insects which may be associated with fruit trees from time to time. For example, the Hemipteron, *Loricula elegantula* Baer., in the family *Microphysidae*, occurs commonly on unsprayed apple and plum trees at Brentwood and near Colchester, Essex. This species has not been noted on fruit in Kent, although it occurs commonly enough on the trunks of oak, beech, lime and coniferous trees in the same county.

Loricula elegantula Baer. is regarded as a local species which is recorded as feeding upon mites and small insects. In the orchard where it occurred, near Brentwood, the tree trunks were partially covered with lichen, and the immature forms and adult bugs were moving up and down the trunks, possibly in search of food. They were not noted feeding, and specimens kept in captivity died without taking food.

The male and female of this bug are dissimilar, the male bearing fully developed wings, while the female is wingless. The male is elongate, with head and pronotum shining, reddish. The wings are fawn coloured, marked with red. The head and pronotum of the female are clear testaceous red, shining. The body is shining black. Length $1\frac{1}{2}$-2 mm.

The adult female occurs in July, August and September, while the male appears in September. It resembles a minute fly.

It is very small and fragile and easily overlooked in the field.

This species is an interesting addition to the list of predaceous insects which sometimes occur on fruit trees, and one wonders what the insect fauna of the fruit tree was in the days before spraying became a matter of routine.

16. Apple Capsid Bug (*Plesiocoris rugicollis* Fall.). The Apple Capsid Bug has a very wide distribution in the British Isles, and it has been recorded from at least twenty-five English counties. It has been recorded also in Wales and Scotland. In Scotland it occurs as far north as the Highlands where it is found commonly at Aviemore, Inverness-shire. There it occurs on the moors, feeding on Bog Myrtle (*Myrica Gale* L.). It is significant that two apple trees growing in the garden of an isolated cottage situated on the moor are not infested by this insect. The Apple Capsid Bug has also been recorded on Bog Myrtle in Wales and Westmorland. Thus it occurs on at least three host plants, namely apple, willow and Bog Myrtle. Many growers may not know that the Bog Myrtle is one of its hosts.

In view of the wide distribution of this harmful bug, it is not surprising that it has been recorded also from the Isle of Man, where it occurs only too commonly on some fruit trees at St. Mary's Port. The varieties of apple affected include Ben's Red, Blenheim Orange, Charles Ross, Ellison's Orange, Newton Wonder and Red Victoria. The grower had detected the scabby apples in previous years, but considered the damage might be due to Apple Scab.

17. Cherry Black Fly (*Myzus cerasi* Fab.). Although the Cherry Black Fly is not nearly so common as it was before the routine tar washes were used, it frequently occurs on unsprayed trees in partially neglected orchards and on cherry stocks in the nursery beds. One reason for its persistence is the fact that it feeds on a number of wild host plants in addition to the cultivated cherry. They include Goosegrass (*Galium aparine* L.), Crosswort (*Galium cruciata* Scop.), Woodruff (*Asperula odorata* L.), and Eyebright (*Euphrasia officinalis* L.). In addition it is of interest to record it feeding on the foliage of two varieties of Japanese cherries, Amanogaira and Okumiyaka, growing in a private garden at Leybourne, Kent.

The Leaf Curling Plum Aphid (*Anuraphis padi* L.) was noted in the same garden on the Japanese cherry, Kanzan.

The writer is indebted to Mr. N. H. Grubb for bringing these interesting observations to his notice.

18. Peach Aphid (*Anuraphis amygdali* Buckton). The Peach Aphid occurred in profusion on some plum trees at East Malling at the latter end of June. The watergrowths and rootsuckers were most severely affected, and the growth of the trees was considerably checked. The *Prunus* species most seriously attacked were *Prunus insititia* L., *P. domesticus* L., *P. spinosa* L., and *P. Padus* L.

It is curious that the peach aphid should establish itself on plum, bullace, blackthorn, etc., since it is usually confined to the peach and nectarine and, in particular, trees growing under glass and on walls in sheltered situations.

19. Aphides Noted on Apples. The necessity of carrying out an adequate winter wash programme, combined with efficient spraying, was emphasized once again in an apple plantation near Chelmsford, Essex. The orchard received a tar wash in January. When the orchard was visited in June, an astonishing number of insect pests was noted including caterpillars of the Winter Moth group, Apple Sucker, and the Brown Soft Scale.

The list of aphides was also very impressive. It included the Green Apple Aphid (*Aphis pomi* De Geer), the Oak-Apple Aphid (*Rhopalosiphum prunifoliae* Fitch), the Rosy Apple Aphid (*Anuraphis roseus* Baker), the Red-Leaf Aphid (*Anuraphis crataegi* Kalt.), the Woolly Aphid (*Eriosoma lanigerum* Hausm.), and a black species, probably the Bean Aphid (*Aphis rumicis* L.).

The fact that so many pests still exist in a few orchards at the present time, points to the necessity of carrying out a winter spray programme with reputable insecticides, which must be applied with modern spraying equipment provided with adequate pressure.

20. Hop Red Spider (*Tetranychus telarius* L.). The importance of the Hop Red Spider is indicated by the fact that it has been referred to in these notes on no less than eight occasions.

Undoubtedly the drought conditions prevailing in the spring and early summer favoured the breeding of the mites, and in many hop gardens bad " spider " infestations were noted early in July, which is very unusual. In a normal " spider " year the infestation does not build up sufficiently to become apparent until August, and in most seasons it is then too late to cause much harm, and hop growers are not unduly concerned about it.

While in most seasons the variety Fuggle is more subject to attack than most other commercial sorts and much damage is caused to that variety, in 1944 the damage extended to other varieties including Golding and Early Bird, particularly in East Kent.

In seasons when the spider starts breeding early in May and the canopy of silk webbing is formed on the leaf undersurfaces, it is very difficult to kill, since the sprays do not penetrate the silk webbing under which the mites live and breed.

Recent experiments prove that the Hop Red Spider can be controlled efficiently by spraying with a 1 per cent. lime-sulphur spray in the second-half of May or in early June, before the mites lay their summer eggs, and before they produce their silken webs on the leaf undersurfaces. Full details of this treatment will be found in Section IV of this Report on page 126.

21. Tarsonemid Mite of Cereals. (*Pediculopsis graminum* E. Reuter, 1900).—This mite was recorded for the first time in Great Britain in last year's Notes on Insect Pests. Since that time, it has been found infesting experimental barley growing on one of the plots at this Research Station, and also in the Bristol Province. It would appear therefore that the distribution of the species is wide spread, having been reported so far from Devonshire, Kent and Gloucestershire.

Advisory Entomologists and others interested in the distribution of this mite are advised to examine stems of cereals (particularly barley) which mature prematurely in July, and it is probable that the mites will be found in numbers around the nodes if the stems are split open. This species is rather difficult to detect and should be sought with the aid of a binocular microscope.

It is curious that a closely allied species of the same genus (*Pediculopsis ventricosus* Newport) should attack man.

Summary.—Notes and observations are given on twenty-one species of insects and mites observed in 1944.

OBSERVATIONS ON THE LIFE CYCLE OF THE APPLE BLOSSOM WEEVIL (*ANTHONOMUS POMORUM* (L.) CURT.)*

By R. M. GREENSLADE†

Introduction.—Apple Blossom Weevil has long been a pest of orchards, and from time to time has been considered one of the most serious. Observations made on the farm at East Malling Research Station showed that it appeared in large numbers and caused considerable loss about 1920, when methods for its control were investigated by Hatton (1921) and Worsley (1922), but became less numerous in the succeeding years. Recently it has again increased in numbers, and there is evidence that this increase is general throughout the country. Certainly it has caused more than usual concern to fruitgrowers in the last few years, and varieties of apple such as Beauty of Bath, Bramley's Seedling and Worcester Pearmain, once thought to be somewhat resistant to attack, are now regularly infested.

The anatomy and general life history of the species were well worked out by Miles (1923) and Speyer (1923, 1925), and it is only necessary here to give an outline of the life history.

Life History.—There is one generation in the year, but according to Speyer (1923, 1925) some individuals may survive into a second season and mate again. He says that about 40 per cent. may have this second mating, but very few survive the second winter. The winter is passed in the adult stage under rough bark, among dead leaves in hedge bottoms, in the crevices of old tree stumps, in tufts of grass and even in the soil, often at some distance from apple trees. When hibernating, the beetles rest head upwards with the legs and rostrum tightly pressed to the body. They prefer slightly humid conditions, but avoid excessive moisture.

On emerging from hibernation in March, the adults of both sexes feed for a time on the developing fruit buds of apple and pear. The immature organs of the flower inside the closed bud constitute the insect's food at this time. A hole is bored into the bud and practically the whole contents of one or more flowers may be eaten, leaving a plainly visible hole, often marked by a drop of exuding juice, and quite distinct from the neat, almost invisible, hole made for oviposition. Pairing takes place at this time and possibly the rich protein of the anthers is necessary for egg development, as is known to be the case in the related species, *Anthonomus grandis* Boh., the Cotton Boll Weevil.

The eggs are laid in April inside the developing flowers. In 1942 they were first found about the middle of the month, but in other seasons may be rather earlier or later. The female beetle, after careful examination of the bud, bores a hole with her rostrum and lays an egg among the anthers of a flower. The hole is bored through leaves, calyx and petals and, as the bud is growing rapidly, the holes soon cease to coincide and the egg is then totally enclosed and protected from predators or spray fluids. The holes in the outer leaves may still be seen when the leaves have expanded. Eggs

* Part of a thesis submitted to the University of London for a Ph.D. degree.

† Late of the Entomology Section, now with Messrs. Pest Control, Ltd.

are laid at any stage of growth of the bud, from the first sign of green at the tips until the pink petals begin to show. In the early stages it is very rare to find more than one egg per bud of six or seven flowers, but later, when individual flowers begin to show, there may be an egg in every flower of the truss. In a bad outbreak 60 per cent. or more of the flowers may be infested. Occasionally two eggs may be seen in a single flower. This was seen twice in about 3,000 buds examined in 1942. The eggs are soft, white and translucent, normally oval in shape, but often distorted into irregular shapes by the pressure of the growing flower. For a few days before hatching, the black head of the larva may be seen within the egg.

The number of eggs laid by a single female may be as low as 20 or 30 (Massee, 1925). Theobald (1909) states that females have been found upon dissection to contain 50 to 60 eggs, but Speyer (1923) maintains that up to 140 may be laid. He quotes a case of a female laying over 80 eggs in a season and then 64 in the following season after a second mating. It is possible that a weevil may not have time to lay her maximum number of eggs in a season when the buds are opening rapidly. It is certainly well known that in a cool season, when the " green bud " stage lasts a long time, there is usually a severe infestation of weevil larvae in the flowers, whereas in a hot spring, when the buds open very rapidly, weevil infestation is not so serious. The earliest eggs hatch in about 13 days, while those laid later in the season may take only 8 days.

The larva feeds on the stamens and pistil of the flower and prevents the petals from opening by biting partly through their bases (Miles, 1923). The petals then dry up and become the well known " capped blossom " which protects the larva and pupa. Normally these capped blossoms fall from the tree after the emergence of the adult beetle, but occasionally specimens may be found in which the receptacle has begun to develop into a small distorted fruit. During the period of full bloom, many damaged flowers may be seen with the stamens partly eaten and one or two petals dead. These are flowers in which the egg was laid too late, and the larva, being unable to prevent the opening of the petals, has perished. The contents of a single capped flower seem to be adequate for the development of the larva, and pupation takes place in the flower as soon as the contents have been consumed.

The adult remains in the blossom for the first day or two until it is thoroughly hardened, and then eats its way out. At this time, the end of May and beginning of June, the adults feed on the leaves, making characteristic markings. A considerable amount of feeding takes place but without serious injury to the tree, which is then in full leaf. During June, the adults begin to go into hiding and remain there more or less continuously until the following March. This may be considered as a period of aestivation followed by one of hibernation, since some weevils reappear on the trees in late September or early October. The numbers seen at this time, however, are very much less than in the spring, or at the time of emergence from the pupae, and it seems that most individuals must remain in hiding throughout the summer, autumn and winter. The weevils will readily shelter in bands of sacking or other material tied round the trunks of the trees, and Massee (1925) made use of this fact to determine at what times the weevils go into hiding. Bands were removed weekly, the weevils counted and the bands replaced. The numbers trapped rose to a peak in late June or early July, decreased in August and fell to a very low figure in September, rising again in October and falling to a still lower level in December, January and February. This showed that the instinct to seek a hiding place is most developed in June and July. Since weevils are observed to be more numerous on the trees in September, it may be assumed that they are not anxious to go into hiding then, hence the low numbers caught ; but in October the falling temperature induces them to seek shelter in the bands. During the winter no weevils would be expected to seek fresh shelter, but in spite of this a few were caught each week, showing that even in winter some weevils move about.

Host Plants and Varietal Susceptibility.—The apple is the main host plant of *Anthonomus pomorum*, but pear is sometimes attacked. Egg laying is rare on pear, but pre-oviposition feeding frequently occurs, probably because the pear buds, being much earlier than apple, provide food at a time when the preferred host plant is not forward enough. Pear buds exude very large quantities of sap from the wounds made by the weevils. This hangs on the buds in droplets and falls on the twigs and stems in such quantity as to suggest the honeydew secreted by a considerable colony of aphides. Isolated crab apple trees in woods are frequently heavily attacked by Apple Blossom Weevil, and this was no doubt the original host plant.

No cultivated variety of apple is immune or even highly resistant to the weevil, but there are slight differences in susceptibility to its attacks. These differences are probably due to the time of blossoming, since varieties such as Lane's Prince Albert are badly infested, whereas Beauty of Bath, which flowers early, is slightly less attacked. An illustration of this was provided by some data obtained from nursery trees at East Malling Research Station (Tydeman, 1937). Forty young trees of Lane's Prince Albert were grown on 18 different clonal rootstocks, the flowering period being slightly different on each rootstock. The total number of blossoms on each tree was counted,

and also the number of " capped " blossoms. The percentage of " capped " blossoms varied considerably from tree to tree, even on the same stock, but in spite of this there were definite significant differences in degree of infestation among the 18 rootstocks. " This result appeared to be quite definitely related to the time at which the trees on the different rootstocks opened their blossoms. It had always been observed in these trials that the trees on the more dwarfing stocks were in full blossom some considerable time before the trees on the more vigorous rootstocks " (Tydeman, 1937). The percentage of infested blossoms on each rootstock is shown in Table I. The rootstock number is the nursery code number of the original seedling from which each set of 40 rootstocks was propagated. The Roman figures refer to two of the East Malling rootstock varieties included for comparison.

TABLE I.

EFFECT OF ROOTSTOCK UPON THE DEGREE OF INFESTATION OF LANE'S PRINCE ALBERT APPLE BY *Anthonomus pomorum.*

Rootstock No.	Per cent. infested.	Rootstock No.	Per cent. infested.
109	3·0	108	12·7
29	5·5	IX	12·9
15	8·1	116	14·8
93	8·2	9	15·9
96	9·1	89	19·4
70	9·2	128	20·3
22	9·6	119	20·7
122	10·0	VII	22·0
90	10·6	112	22·3

Significant difference 8 per cent. (approx.).

Observations in 1941-2.—It is evident from the foregoing account of the life history of the Apple Blossom Weevil that, although much was known about the species, some points were not clear. For the purpose of controlling the pest it was necessary to know when the adult beetles appeared on the trees, for how long they continued to come out of their winter quarters, and the duration of the egg-laying period. To obtain this information was the main object of the work carried out at East Malling Research Station in 1941 and 1942. Most of the observations were made on a plot of Lane's Prince Albert apples on which there was normally a rather high infestation of Apple Blossom Weevil. Supplementary observations and counts were made on other plots and neighbouring farms.

The following records were made every two days in 1942 :

1. **The number of adult weevils on the trees.**—This was determined by shaking branches over a beating tray, following a random course from tree to tree for 20 minutes, and counting the weevils so obtained. The sample was subject to considerable variations owing to weather conditions, but gave a good idea of the period of activity of the adult weevils. On several days this record had to be omitted, because of high winds in which it was impossible to use a beating tray.

2. **Buds with feeding punctures.**—A sample of 50 fruit buds was picked at random and examined for feeding punctures and eggs. This showed how long the weevils fed before egg laying.

3. **Buds with eggs.**—From the same sample. The very few buds which had both feeding punctures and eggs were included in this category. Eggs are not normally laid in buds damaged by feeding.

4. **Buds or blossoms with larvae.**—From the same sample of 50 fruit buds. By the 18th May these buds had become trusses of flower buds, but in order to compare with previous records, the number of *trusses* containing eggs was noted without regard to the fact that in some cases more than one flower might be infested. At this time of course the infested flowers were plainly visible, and it was difficult to be unbiassed in picking. Samples were therefore picked by sense of touch, without looking at the tree. From 20th May it became more important to notice pupation and the sample taken from that date was 50 " capped " blossoms, that is, blossoms known to be infested. The similarity of the figures for 18th and 20th May in Fig. 5 is therefore fortuitous.

5. **Blossoms with pupae.**—The number of pupae in the same sample of 50 buds.

6. **Blossoms with adults.**—Adults in soft condition and not yet ready to escape from the bud.

These records were sufficient to give the required information. Their value as quantitative records will be discussed later. The information gained is shown graphically in Fig. 5.

Emergence of adults from hibernation.—The first adult was seen on 15th March, 1942, one day

FIG. 1.
"Capped" apple blossom containing larvae of *Anthonomus pomorum* × 1.

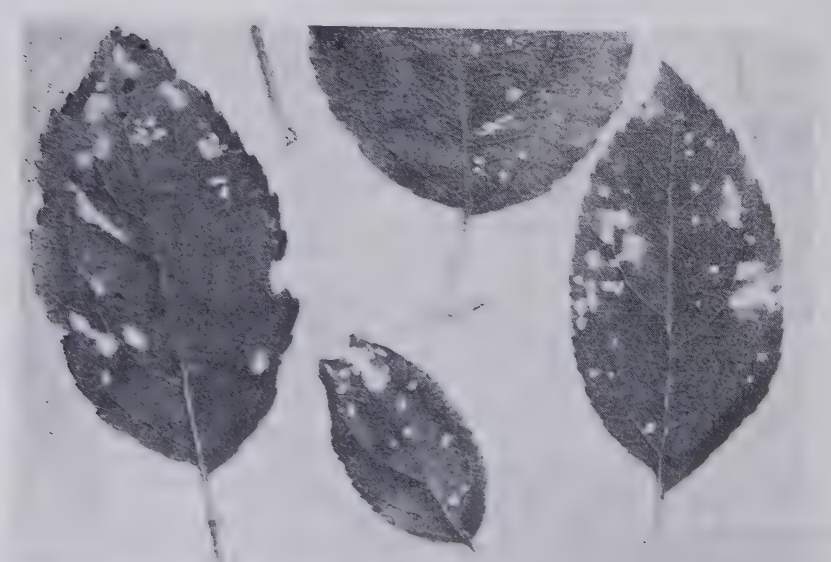


FIG. 2.
Holes caused by post-blossom feeding of *A. pomorum* adults × $\frac{3}{4}$.

ter than in 1941. In the next few days a very few weevils were seen, but they were sluggish and arcely moved, though there was no doubt from their position on the smaller shoots that they had merged from hibernation. On 25th March, 1942, the temperature rose and many active weevils ere seen. Even yet there was no sign of feeding, and most of the weevils became motionless when the n was obscured by cloud. Adults remained on the trees until the 6th May, after which no more ere seen until 3rd June when the next generation began to emerge. It is probable that the weevils ntinue to come out of hibernation for a period of 5 weeks, since there was a general rise in numbers the samples from 15th March to 20th April, and also pairing was noted from 25th March to 26th pril.

On 2nd April petroleum oil spraying against the eggs of the Apple Capsid Bug, *Plesiocoris rugicollis*, reduced the number of weevils on the trees. That the weevils were actually killed by the spray nd not merely repelled by the oily deposit is shown by the rapid rise in numbers immediately after praying, due to the continued immigration of fresh insects while the deposit was still present on the rees.

Feeding and egg laying.—The first injured bud was seen on 27th March, 1942, but, as pairing ad been noted on the 25th, it is probable that feeding had actually started a few days before 27th.

The first eggs were found on 12th April, 18 days after the date on which pairing was first noticed. Between 14th and 16th April a sharp rise in the number of eggs occurred, from 2 to 10 in a sample of 50 buds, and thereafter the number remained fairly constant until 24th April when hatching began. This showed that, though there is a fairly long egg-laying period, yet many eggs were laid within two days, a very important fact when considering control measures. In 1941 a single egg was found on 31st March in a sample of 50 fruit buds, but no more were seen until 16th April.

Larva and pupa.—The first larva was seen on 24th April and the last on 1st June. The numbers present, as estimated by a sample of 50 buds, increased rapidly until 18th May. Twenty-six days elapsed between the first larva and first pupa, 14 between the highest number of larvae and the highest number of pupae, and about 12 between the last larva and last pupa. The larval stage therefore lasts as long as 26 days for the earliest individuals, but may be considerably less for the later ones. The difference in date between the peaks of larvae and pupae in Fig. 5, if this may be taken to represent the length of the larval stage at this date, gives 14 days, which is near the 15 to 29 days given by Miles (1923) in his study of the life history of *Anthonomus pomorum*. The first adult was found 14 days after the first pupa. The following table summarizes the life history in 1942.

	Date.	Days.
Weevils present on trees	15/3-6/5	53
Feeding before oviposition	27/3-12/4	16
Pairing noted	25/3-26/4	33
First pairing to first egg	25/3-12/4	18
Eggs present	12/4- 8/5	27
First egg to first larva	12/4-24/4	12
Larvae present in buds	24/4- 1/6	39
First larva to first pupa	24/4-20/5	26
Pupae present	20/5-13/6	25
First pupa to first adult	20/5- 3/6	14

From this it can be seen that the various stages of development, at least of the earlier individuals, had the following duration :

Egg	12 days (8 to 13).
Larva	26 days (15 to 19).
Pupa	14 days (5 to 10).

The figures in parentheses are those quoted by Miles (1923). The corresponding figures for the later individuals would be shorter. The first two figures given by Miles for instance, are those for eggs laid on 5th April, 1921 and on 28th April, 1922 respectively. If the egg stage lasts 12 days and eggs are present for 27 days, then egg laying must continue for at least 15 days, though as has been shown, the majority may be laid within two days. The average duration of the stages of development in any one year will depend upon climatic conditions. No doubt, if weather conditions were correct for egg laying from an early date, the number of eggs laid would rise gradually to a peak. If bad weather delayed egg laying until after most of the females were ready for oviposition, then most eggs would be laid within a few days of the rise in temperature, as in 1942.

As soon as an efficient control method for Apple Blossom Weevil is devised, the following information will be needed. 1. When will the majority of weevils have reached the apple trees ? i.e. how soon can control treatments be applied? and 2. When is the peak of egg laying, after which it will be

useless to apply a treatment? The latter date is most important when the peak of egg laying comes suddenly as in 1942. This information can only be obtained by following the course of egg laying for some years by some sampling technique such as that described, but observations should be correlated if possible with the climatic conditions necessary for egg laying. It should eventually be possible to give the fruitgrower a method for determining these two dates without the necessity for tedious sampling.

Control Measures against *Anthonomus pomorum*.—No control method, effective under all conditions, has yet been devised, and further attention was given to the problem in 1941 and 1942. As mentioned before, the larva and egg cannot be attacked and control measures must be directed against the adult weevils. Many methods have been tried in the past and Massee (1925) compared those available at that time. Shaking the trees and collecting the weevils proved useless, and poultry could not be induced to feed on them. Lime-washing did not deter the weevils, which continued to lay eggs even when coated with lime, and lead arsenate as a stomach poison was not effective as they feed by boring right into the bud, discarding the outside piece of leaf upon which the arsenate is deposited (Miles, 1923). The most effective method of control was to trap the weevils in bands of sacking or other material tied round the trees to provide suitable winter quarters. The bands were

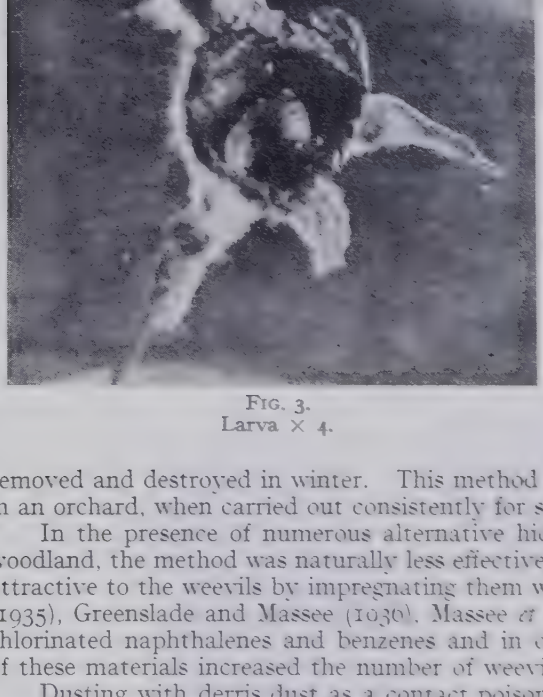


FIG. 3.
Larva × 4.

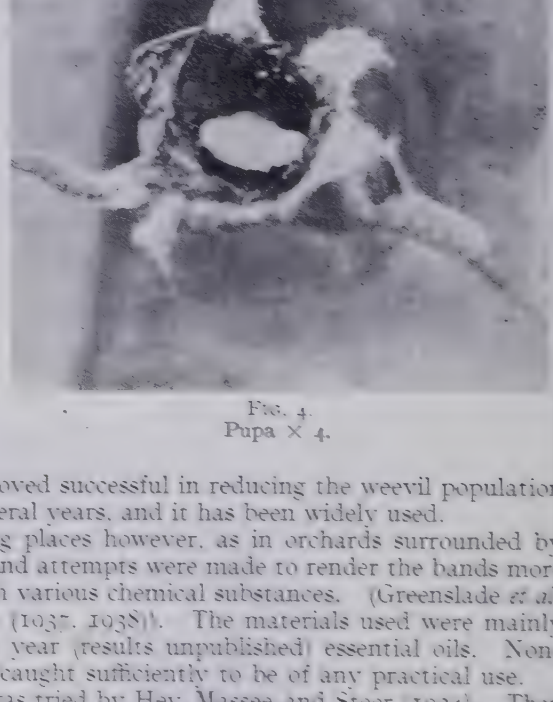


FIG. 4.
Pupa × 4.

removed and destroyed in winter. This method proved successful in reducing the weevil population in an orchard, when carried out consistently for several years, and it has been widely used.

In the presence of numerous alternative hiding places however, as in orchards surrounded by woodland, the method was naturally less effective, and attempts were made to render the bands more attractive to the weevils by impregnating them with various chemical substances. (Greenslade *et al.* (1935), Greenslade and Massee (1936), Massee *et al.* (1937, 1938)). The materials used were mainly chlorinated naphthalenes and benzenes and in one year (results unpublished) essential oils. None of these materials increased the number of weevils caught sufficiently to be of any practical use.

Dusting with derris dust as a contact poison was tried by Hey, Massee and Steer (1934). They obtained a reduction of "capped" blossoms of just over 50 per cent. of the number present on untreated trees. Dusts were applied on 30th March and 7th April, only the latter being considered effective.

Experiments in 1942.—Dusting.—Derris dust was tried again in 1942 during the egg laying period. Three trials were made. The first, on an acre of 25-year-old bush apple trees of the varieties Lane's Prince Albert, Bramley and Newton, was carried out on 14th April, just after the first eggs were found in the field. There was no wind, and a perfect cloud of dust formed and settled evenly all over the trees. A proprietary derris dust was used, the minimum rotenone content of which was guaranteed as 0·25 per cent. Samples of buds taken on 10th and 21st April showed no diminution of infestation of dusted trees as compared with untreated controls, and over 40 per cent. of blossoms were "capped".

The second plot, half an acre of cordon trees, was dusted on 15th April. Hand dusting machines of the rotary type were used and 50 pounds of dust applied on half an acre. A sample of 21,000

lowers counted on 26th May showed that 25 per cent. were injured by *Anthonomus pomorum*. The hird small plot of nursery trees was dusted on 16th April, but was heavily infested.

The dust was applied to the first plot as soon as the first eggs were seen and before the sudden ncrease in egg laying. The time of application was therefore correct and weather conditions were deal. The failure to control the insect must therefore have been due to the insecticide, or to re-nfestation after the coating of dust had lost its effectiveness. The main egg laying occurred immedi-tely after the dusting; there was no rain for some time and it seems therefore that derris dust of ow rotenone content is ineffective against apple blossom weevil. Possibly a dust of 0·8 or 1 per ent. rotenone content might give better results.

Experiments in 1941-42.—Repellants.—Owing to the uncertainty of the weather at the beginning f egg laying, and because the weevils come out of hibernation over a long period, the application

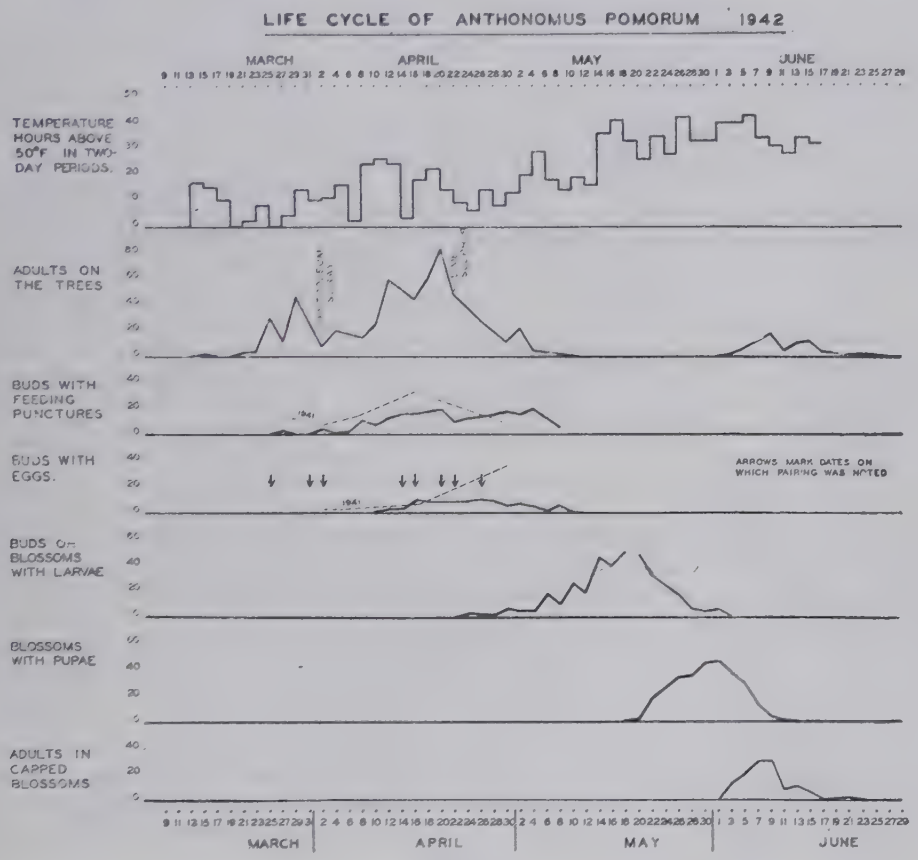


FIG. 5.

Life cycle of *A. pomorum* 1942.

of contact poisons as dusts is very difficult. It would be a great advantage if it were possible to apply a repellant to the trees to keep the egg-laying females away from the buds.

Very little information seemed to be available on the subject of repellants against insects of this type. The first two materials tried in 1941 were beta-naphthol, chosen because it had been repellant to weevils, at a high concentration, in the trapping experiments already mentioned (Massee *et al.* (1938)), and lime-sulphur which had been recommended for this purpose by Balachowsky and Mesnil (1935). A preliminary trial with beta-naphthol at 0·5 per cent. on 16th May, 1940, had produced slight but not harmful scorching of the leaves. In 1941 the concentration was reduced to 0·25 per cent., as it was necessary to avoid all risk of injury to the trees then available. Lime-sulphur was used at 5 per cent. At the same time a spray of 2 lb. ground derris root and 5 lb. soft soap per 100 gallons water was tried as an alternative to derris dust, being more easily applied in the weather conditions generally prevailing in March and early April. Treatments were applied on 4th April, and though one egg had been found on 31st March, no more were found until 16th April. The effect

of the treatments was judged by counting the number of infested fruit buds in a sample of 50 picked at random after egg laying was complete. Later 500 blossoms were counted in each treatment and the number infested by weevil larvae recorded. The results were as follows :

Treatment.	Per cent. fruit buds containing eggs on 29.4.41.	Per cent. blossoms capped. 12.6.41.
4.4.41.		
Derris spray	68	13
Beta-naphthol	44	9
Lime-sulphur	34	15
Untreated trees	72	15

Since the treatments appear in a different order when sampled by the two methods, it is evident that one or both methods must be inadequate, but it seemed that the infestation was slightly reduced by beta-naphthol, and this material was worth a further trial. The question of suitable sampling methods is discussed later.

In 1942 a laboratory trial was first carried out with cut shoots of apple (Beauty of Bath) kept in a warm greenhouse until the buds were in the right stage for the weevils to feed on them. In each treatment a number of fruit spurs was dipped and the whole shoots, each bearing a number of differently treated spurs, were placed in moist sand in a cage. The weevils were then placed in the cage and had the choice of untreated buds or buds treated with each of the experimental materials. They were left in the cage from 12th to 18th March and the buds were then examined, with the following results. As whole spurs were dipped, the number of buds in each treatment is not the same.

Treatment.		Total buds.	Injured buds.
Beta-naphthol	0·25%	11	0
Tetramethylthiuram disulphide	0·25%	11	1
Lime-sulphur	7·0%	24	11
Nicotine	0·06%	16	2
Pyridine	0·12%	12	6
Hexachlorethane	0·25%	14	0
Control (untreated)		35	15

The cage was big enough to avoid any fumigation effect, but it is possible that, in the absence of weathering, some of the treatments might be more effective than would have been the case in the open. All the treatments except lime-sulphur and pyridine seemed hopeful, and while nicotine was considered too volatile to be of use, the remainder were included in a field trial.

The materials used in the field trial in 1942 were beta-naphthol 0·25%, tetramethylthiuram disulphide 0·25%, paradichlorobenzene 0·25%, naphthalene 0·25% and hexachlorethane 0·25%. At the same time a derris dust and a pure silica dust were applied for comparison. The spray materials were dissolved in a very small quantity of benzene and emulsified with water in a laboratory mill, with the exception of the tetramethylthiuram disulphide, which was in the form of a commercial spraying preparation. The sprays were applied to a plot of Lane's Prince Albert apple trees on 15th April, 1942, and records were made similar to those in 1941. Fifty fruit buds were picked from each treatment and examined for eggs, and later, 10,000 blossoms per treatment were examined for larvae. These two samples gave the following results.

Treatment.	Per cent. buds with eggs.	Per cent. blossoms capped.
Control row (west)	—	9·8
Beta-naphthol	32	11·1
Naphthalene	22	7·8
Tetramethylthiuram disulphide ..	28	5·5
Paradichlorobenzene	30	11·3
Hexachlorethane	4	6·1
Silica dust	18	6·2
Derris dust	20	9·9
Control row (east)	18	5·6

As in the previous year's trials, the treatments appear in a different order when sampled by different methods, suggesting that the sampling method was inadequate. The high blossom counts for paradichlorobenzene and beta-naphthol are each due to the presence of one tree carrying an unusually high population of weevils. None of the treatments differ significantly from the controls.

ndomization of plots was not attempted, because the purpose of the experiment was not to compare terials known to be insecticidal, but to discover whether the materials possessed any repellant perties at all. It was unfortunate that the general level of infestation over the plot was so low, t it seems that none of these materials will give protection for the tree during the egg laying period. is possible that two applications with an interval of about a week might have given better protection, d this should be tried in future.

Sampling Methods.—Two sampling methods were used, the examination of fruit buds for eggs d the counting of capped blossoms. The first was limited by the time taken to dissect and examine e buds with a binocular microscope and still more by the amount of damage done to the trees by e removal of so many buds, each representing a complete truss of flowers. For these reasons only e sample of 50 buds could be taken on each sampling day during the life-history observations, d only one from each treatment in the experiments on control measures. In Fig. 5 the number larvae in 50 buds shows alternate rises and falls. As larvae were hatching all the time, the numbers ould show a steady rise to a peak, and if sufficient samples had been taken there would probably ve been such a rise in the mean number. If greater accuracy is needed, future work should include trial to determine the minimum number of samples required. This number might be too high to be practical use, since the distribution of weevils in an orchard is generally very uneven, and is com- icated by the presence of a few highly infested trees in an otherwise mildly infested orchard. The amination of " capped " blossoms for determining the progress of the life history is a simpler matter, nce the blossoms are known to be infested, and a sample of 50 is adequate to determine the proportion larvae and pupae. The accuracy of the counts of capped blossoms for estimating the degree of festation of a plantation also suffers from the same uneven distribution of the weevils. On a row trees in the experimental plot, the numbers of capped blossoms per 1,000 were 72, 54, 69, 30, 23, 1, 9, 66, 105, 104, and on another block of five trees they were 78, 82, 308, 32, 65. With this variation is difficult to detect slight differences in population. In the experiment on repellants for instance, ne infestations on the differently treated plots, varying from 5·5 to 11·3 per cent., did not differ gnificantly. Possibly the variation from tree to tree might be less in a high infestation when 50 per ent. or more of the buds are capped. For testing the effect of control measures, however, great ccuracy is not essential, as, in the present state of investigations, any really effective measure would e obvious without fine sampling methods.

Summary.—1. An account of the life history of *Anthonomus pomorum*, is given, showing that nformation was lacking on the habits of the adult weevils.

2. Biological observations in 1941 and 1942 showed that over-wintered adults were on the rees for a period of 53 days, and that egg-laying continued for at least 15 days, though a high pro- ortion of the total were laid within two days. The approximate duration of the stages was: egg 2 days, larva 26 days, pupa 14 days, these figures being somewhat reduced for the later individuals.

3. Dusting with derris powder under favourable conditions was not effective in reducing the mount of damage to the blossom of four different plots of trees.

4. Six materials were tried as possible repellants to keep the weevils away from the trees. None vas successful.

5. The methods used for sampling the weevil population are briefly discussed.

Acknowledgements.—I am indebted to Dr. A. M. Massee for much valuable information not ncluded in his published work on Apple Blossom Weevil, and to Dr. H. Shaw for advice and help in n the preparation of the spray materials.

References.

Balachowsky, A., et Mesnil, L. (1935). *Les Insectes nuisibles aux Plantes Cultivées*, 1 : 28-39.

Greenslade, R. M., and Massee, A. M. (1936). " Studies of impregnation of tree banding materials. II. Apple Blossom Weevil and Codling Moth experiments in 1935." *Rep. E. Malling Res. Sta. for 1935*, 177-83.

——— ——— and Thomas, F. J. D. (1935). " Apple Blossom Weevil experiments in 1934. Impregnation of tree banding materials." *Rep. E. Malling Res. Sta. for 1934*, 180-4.

Hatton, R. G. (1921). " Control of the Apple Blossom Weevil." *J. Kent Farmers' Union*, **9** : 176-7.

Hey, G. L., Massee, A. M., and Steer, W. (1934). " An experiment on the control of the Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.) by means of a derris dust." *Ann. Rep. E. Malling Res. Sta. for 1933*, 217-19.

mms, A. D. (1918). " Observations on *Pimpla pomorum* Ratz., a parasite of the Apple Blossom Weevil." *Ann. appl. Biol.*, **4** : 211-27.

MASSEE, A. M. (1925). "The control of the Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.)." *Ann. Rep. E. Malling Res. Sta. for 1924*, 145-57; and *J. Pomol.*, **4** : 1-14.

——— GREENSLADE, R. M., and BRAIR, J. H. (1937). "Studies of impregnation of tree bandin materials. III. Apple Blossom Weevil and Codling Moth experiments in 1936."— *Ann. Re E. Malling Res. Sta. for 1936*, 232-9.

——— ——— and DUARTE, A. J. (1938). "Studies of impregnated tree banding materials. IV Apple Blossom Weevil and Codling Moth experiments in 1937." *Ann. Rep. E. Malling Re Sta. for 1937*, 213-18.

MILES, H. W. (1923). "Observations on the bionomics of the Apple Blossom Weevil, *Anthonomu pomorum* Linn." *Ann. appl. Biol.*, **10** : 348-69.

SPEYER, W. (1923). "Ueber die Lebensdauer des Apfelblütenstechers (*Anthonomus pomorum* L und die Entwicklung seiner Geschlechtsorgane." *Zeitschr. Schädlingsbekämpfung* I, nr. 2 68-70.

——— "Die Lebensdauer des Apfelblütenstechers (*Anthonomus pomorum* L.)." *Nachrichtenb deutsch. Pflanzenschutzdienst* V, nr. 11, 89-91.

——— (1926). "*Pimpla pomorum* Ratz. (Ichneumon.), der Parasit des Apfelblütenstechers *Anthonomus pomorum* L. (Coleopt.)." *Arb. biol. Reichsanst. Land- u. Forstw.*, XIV, nr. 3 231-57.

TYDEMAN, H. M. (1937). "Studies on new varieties of apple rootstocks." *J. Pomol.*, **15** : 165-9

WORSLEY, K. P. (1922). "Apple Blossom Weevil experiments." *J. Kent Farmers' Union*, **12** : 30-1

HOPS

CULTURAL TRIALS WITH HOPS

IV. THE EFFECT OF DISTANCE OF PLANTING AND HARD AND LIGHT PULLING ON BREWER'S FAVOURITE

By F. H. BEARD

Introduction.—From 1928 onwards several trial plots have been planted at East Malling t study the effect of the various cultural practices, such as distance of planting, number of bines to string, severity of pulling, and time of cutting, involved in the growing of hops. Data obtaine from a manurial trial in which some of the hills had been killed by disease indicated that the distanc between the hills had a considerable effect on the yield per hill (Amos and Hoblyn, 1928). As result of this it was decided to investigate the effect of distance of planting on varieties of differen vigour. A report on a trial with an early variety of moderate-weak vigour having short laterals ha already been published (Beard, 1937). The present paper deals with the effect on Brewer's Favourit (OP21), a more vigorous and later variety producing long and very fruitful laterals. A trial with very strong growing late variety is still in progress.

In the Brewer's Favourite trial it was decided to combine in a single trial hard and light pullin and two distances of planting.

Experiment.—The trial was planted in October, 1931, but the pulling treatments were not starte until 1935, though the crops were recorded in 1934. The four treatments were arranged in fiv randomized blocks. Each plot consisted of two rows of either 7 or 14 hills, according to distance planting. Guard hills were placed at the ends of the plot rows.

The treatments were :

A. 7 ft. by 7 ft. Hard pulling.
B. 7 ft. by 7 ft. Light pulling.
C. 7 ft. by 3 ft. 6 in. Hard pulling.
D. 7 ft. by 3 ft. 6 in. Light pulling.

Hard pulling consisted of the removal of all the forward and intermediate bines and the trainin up of the very late bines. With light pulling only the most forward bine was removed before furnishin the strings. The hops were grown on the "Butcher" wirework system with 7 ft. alleys and 13 ft. 6 in top wire.

Records.—From 1934 onwards the crop from each plot was picked and dried separately and the ld per acre, as shown in Table I, was calculated from the weight of dry hops.

From the bushels of green hops picked and the weight of dried hops, the number of bushels of een hops needed to yield a cwt. of dried hops was calculated. Whilst in some seasons more bushels re needed than in others (e.g. a mean of 89 in 1935 and 128 in 1937) there were no significant differ- ces between the treatments. Data from various trials, both at East Malling and Wye, all suggest at the bushels : cwt. ratio and the P.V. are varietal and seasonal characters and are not influenced cultural treatments, except when these cause the hops to be picked before they are fully ripe. mples of hops from the two extreme treatments (A. and D.) were saved for analysis. There was no nificant difference in P.V. between the treatments.

Cropping was satisfactory except in the seasons 1941 and 1944, when yields at East Malling were nerally low owing to unfavourable weather conditions.

From 1938 onwards the forwardness of the bine at the end of May or early June, and the time hen the bines were reaching the top wire, were recorded.

Effect of Spacing.—Close planting gave significantly heavier yields than wide spacing in 1934, 35, 1937, 1938, 1939, 1940 and 1941. (See Table I.) In 1936, 1942, 1943 and 1944 the increase as too small to be significant. The significant increases varied from 4·22 cwt. per acre in 1939 to 83 cwt. per acre in 1935. Over the 10 year period 1935-44 the mean increase in yield due to close anting was 2·32 cwt. per acre. Although the yield per acre was increased by close spacing, the yield r hill was decreased, the mean yield per hill for the 10 year period being 2·50 lb. at 7 ft. by 7 ft. id 1·39 lb. at 7 ft. by 3 ft. 6 ins. After the trial had been running for a few years it was seen that the ose planted hills produced very matted bine and, as Brewer's Favourite is highly susceptible to owny Mildew, there was a considerable risk of loss of crop should a " Downy Mildew Year " occur. was therefore decided from 1938 onwards to train up only one bine per string on the closest planted ots. Results from another trial had shown that the number of bines had no effect on the yield f an early weak variety when close planted (Beard, 1937).

Effect of Severity of Pulling.—(*a*) **On Vigour.**—It was always obvious that the bine on the ghtly pulled plots was more forward up to the time the hops reached the top of the strings. From 38 onwards the bines were measured at the end of May or early June (see Table II). In 1938 all lls were measured, but the figures showed that it was sufficient to measure half of each plot (1 row). he mean length of bine for the plots with hills 7 ft. by 7 ft. was always lower than that for the ft. by 3 ft. 6 in. plot with the corresponding pulling treatment. This is due to the fact that the hills in ie 7 ft. by 7 ft. plots have two bines per string, whilst those in the 7 ft. by 3 ft. 6 in. have only one ine. If only the more forward bine on each string in the 7 ft. by 7 ft. plots is considered, the measure- ients are similar to the corresponding 7 ft. by 3 ft. 6 in. plots. Table III gives the dates at which o per cent. and 90 per cent. of the bines had reached the top wire and shows that the differences in orwardness of bine noted in the earlier records persisted. In spite of the differences in forwardness f bine, there has been little variation in the dates at which the plants in the different treatments ame into burr and hop. In 1935, 1936, 1937, 1941, 1942 there was no difference at all, but in 1938, 939, 1940, 1943, and 1944 the hard pulled hills were from 1-4 days later in coming into burr and rom 1 to 2 days later in coming into hop.

(*b*) **On Cropping.**—Light pulling gave significantly heavier crops in 1939, 1940, 1941, 1943, and 944. In 1939 and 1944 the increase was only significant with wide spacing. The effect of severity f pulling has, with the exception of 1939, only been significant in the years of low yields. Light ulling gave the greatest increase over hard pulling in 1941, when it was 4·23 cwt. per acre. Over he ten year period light pulling has given a mean annual increase over hard pulling of 2·33 cwt. er acre at 7 ft. by 7 ft. and 1·61 cwt. per acre at 7 ft. by 3 ft. 6 in.

Discussion.—It is interesting to compare the effect of spacing in this trial with that recorded in nother trial (Beard, 1937) with the rather weak growing early variety L21, which has only short aterals. With L21, the mean annual differences over a six year period were, between 9 ft. and 6 ft. n the rows, 4·41 cwt. per acre, and between 6 ft. and 3 ft., 3·11 cwt. per acre. In the present trial he mean annual difference between 7 ft. and 3 ft. 6 in. in the rows was 2·70 cwt. per acre, where here was hard pulling, and 1·98 cwt. per acre where there was light pulling. The lightly pulled plots orrespond most closely to that of the L21 plots. Thus L21 at 7 ft. by 3 ft. gave an annual yield f 3·11 cwt. per acre more than when planted 7 ft. by 6 ft., and Brewer's Favourite plots, when lightly ulled at 7 ft. by 3 ft. 6 in., gave an increase of 1·98 over plots at 7 ft. by 7 ft. This indicated that, s might be expected, the more vigorous the variety the greater use it can make of wider spacing. Vith increasing vigour of a variety the yield per hill rises rapidly with wide spacing and more rapidly pproaches a point at which it compensates for the fewer hills per acre. This is borne out by data btained from a trial with a very vigorous late variety which appears to be able to make full use of 7 ft. by 9 ft. plant.

Table I.

Brewer's Favourite. Distance of Planting and Severity of Pulling.
Mean Yields 1933-44. Cwt. per acre.

Treatment.	1934*.	1935.	1936.	1937.	1938.	1939.	1940.	1941.	1942.	1943.	1944.	Mean 1935-44.
A. 7′×7′ Hard pulling ..	23·36	22·43	21·09	19·39	20·18	21·89	17·40	12·81	21·55	16·22	12·25	18·52
B. 7′×7′ Light pulling ..	23·02	21·87	22·57	20·07	21·88	25·65	20·64	17·46	23·36	19·61	15·42	20·85
C. 7′×3′ 6″ Hard pulling	26·88	23·93	22·32	22·56	24·72	27·08	19·90	16·56	23·25	17·12	14·74	21·22
D. 7′×3′ 6″ Light pulling	27·22	24·03	22·68	21·88	24·72	28·89	23·79	20·38	25·38	20·29	16·21	22·83
Gen. Mean	25·12	23·10	22·17	20·97	22·88	25·88	20·43	16·70	23·38	18·31	14·66	20·85
Effect of Distance ..	××	×	—	×	×××	××	××	×××	—	—	—	—
Effect of Pulling ..	—	—	—	—	—	×	××	×××	—	×××	×	

* No differential pulling in this year.
×=significant $P<0·05$.
××=highly significant $P<0·01$.
×××=very highly significant $P<0·001$.

Table II.

Brewer's Favourite. Distance of Planting and Severity of Pulling.
Average length of Bines in cm., 1938-44.

Treatment.	1938. May 25th.	1939. May 24th.	1940. May 29th.	1941. June 16th.	1942. May 29th.	1943. May 25th.	1944. June 5th.
A. 7′×7′ Hard Pulling	114	129	141	149	196	149	175
B. 7′×7′ Light pulling	162	184	216	200	231	200	236
C. 7′×3′ 6″ Hard pulling ..	125	144	152	159	194	159	182
D. 7′×3′ 6″ Light pulling ..	167	199	233	219	239	219	247
Mean	142	164	186	182	215	182	210

Table III.

Brewer's Favourite. Distance of Planting and Severity of Pulling.
Forwardness of Bine 1939-44. Dates at which 50% and 90% of bines had reached the top of the strings.

	1939.		1940.		1941.		1942.		1943.		1944.	
	50%	90%	50%	90%	50%	90%	50%	90%	50%	90%	50%	90%
A. 7′×7′ Hard pulling	3/7	12/7	12/7	29/7	25/7	8/8	1/7	9/7	14/7	26/7	23/7	8/8
B. 7′×7′ Light pulling	23/7	3/7	28/6	22/7	11/7	28/7	25/6	3/7	28/6	16/7	11/7	25/7
C. 7′×3′ 6″ Hard pulling	30/6	7/7	12/8	29/8	21/7	8/8	29/6	9/7	10/7	24/7	19/7	2/8
D. 7′×3′ 6″ Light pulling	21/6	3/7	28/6	19/8	9/7	21/7	25/6	5/7	24/6	8/7	11/7	25/7

The distance of planting should therefore be varied to suit the vigour of the variety grown.

The effect of the pulling treatments has, on the whole, been less than the effect of spacing and it as been more marked with wide spacing. Over the ten year period the mean annual yields for wide pacing with light pulling and close spacing with hard pulling do not differ appreciably ; wide spacing ith heavy pulling has given the lowest yields, and close spacing with light pulling the heaviest yields.

For Brewer's Favourite the relatively wide spacing of 7 ft. by 7 ft. appears to be the most satisactory, provided only light pulling is carried out. The increase in yield due to closer planting at ft. by 3 ft. 6 in. is probably not sufficient to compensate for the increased capital outlay for the extra lants needed and for the increased working costs due to the extra labour needed for dressing and tringing.

The several new varieties now being grown increasingly under commercial conditions all possess listinct habits of growth and vary in vigour, so that each requires its own particular method of growing. Data already obtained, and in the course of being obtained from the various cultural trials t East Malling, are proving most useful in indicating what modifications of the usual hop-growing outine are likely to be the most beneficial for a particular variety.

Acknowledgements.—The writer is indebted to Mr. T. N. Hoblyn for help in the planning of the rial. Miss J. L. Edgar was responsible for the statistical examination of the data from 1934 to 1938, nd Mr. S. C. Pearce from 1938 onwards.

Summary.—An account is given of a trial of two distances of planting combined with hard and light pulling on the variety Brewer's Favourite.

Both spacing and pulling treatments influenced the yield, but spacing had, on the whole, the greater effect. The pulling treatments caused big differences in the forwardness of the bine throughout the growing season, but caused practically no variation in the time the plants came into burr and hop. The effect of distance in this trial is compared with that obtained in earlier trials with a variety of a different habit of growth.

Wide spacing combined with light pulling appears to be the most suitable method of growing Brewer's Favourite. Mention is made of the need for adjusting the distance of planting according to the vigour and habit of the variety to be grown.

References.

Amos, J. and Hoblyn, T. N. (1928). "Manurial Trials with Hops." *Rep. E. Malling Res. Sta. for 1926-7*, II Supplement, 165-76.

Beard, F. H. (1937). "Cultural Trials with Hops. II. The Effect of distance of planting and number of bines : a final report on the trial with the seedling L21." *Rep. E. Malling Res. Sta. for 1936*, 117-25.

Section IV

BULLETINS FOR FRUITGROWERS

A SURVEY OF PLANTING PROBLEMS*

By R. G. HATTON

A SURVEY of planting problems covers almost every aspect of fruitgrowing. It is not proposed t deal in detail with soil, site, climate, systems of layout and culture, labour and transport facilitie as these subjects are too wide for a short article of this nature but it must be emphasized that thes are primary and all-important considerations as they should determine what kinds and varieties o fruit we can grow in any particular location, or indeed whether we should attempt to grow fru there at all.

This survey is given from the standpoint of one whose primary interest has been the fruitgrower material and its individual idiosyncrasies. I find myself standing at a very appropriate mileston whence many of us can look back over the past 30 or more years—the once predicted profitable lif for the then comparatively new commercial plantations of bush apples and pears on " paradise " an " quince ". During the past few years, in a strenuous wartime effort to produce the highest possibl tonnage of saleable fruit from our established orchards, we have had to get busy thinning, frame working, spraying, cultivating and grubbing. In most cases this was not because old age had over taken these plantings, but because they were planned with inadequate knowledge of our plant materia and all the interactions of their environment, and diverse cultural operations employed.

Here are two typical layouts recommended 32 years ago as the "very best" by two protagonist of the renaissance of fruitgrowing in Kent. The ideal plantation was :

Bramley's Seedling on " paradise ", 24 ft. square.
Beauty of Bath in centre as pollinator.
Baldwin Black Currants at 6 ft. apart in tree rows.
Lancashire Lad Gooseberries at 4 ft. apart down the intermediate alleyways.
Royal Sovereign Strawberries at 3 ft. from Gooseberries.

True these were the days of hand digging at from 16s. to 25s. per acre, and of levelling and hand hoeing at from 4s. 6d. to 12s., though the idea of using a single horse " nidget " to " help out " wa beginning to grow.

The orchard plan suggested standard sweet cherries at 30 feet " middled " throughout with apple or plums at 15 feet. Bush pears as " fillers " at 7 ft. 6 in. have not infrequently completed such scheme. The economic and labour problems of the first Great War caught hundreds of acres of suc intensively planted fruit before ever they had the chance of justifying their existence. Many grower's dream of a weedless, closely pruned fruit garden vanished for ever and only remained as nightmare to develop into the neglected orchard. After a brief and usually disastrous effort to us the pig as an effective substitute for the fork and hoe, progressive growers got busy transplantin or grubbing on a large scale, planning new plantations adapted to the elastic cultural treatment which require space and mechanical implements for their effective use.

Whilst economic problems and the call for new systems of management were gradually forcin the grower to readjust his planting plans, the ascertained facts of research about the grower's materia and its specialized reactions to soil, environmental and cultural conditions, were establishing a numbe of basic principles which would profoundly influence planting schemes. Let us see how our " bes plans " of 30 years ago look in the light of these facts.

First, we have now learned quite a lot about the potentialities of our standardized trees unde given cultural and environmental conditions. The protagonists of the bush plantation on broadlea paradise and on quince had recommended 12, nay even 8, feet as a suitable planting distance. W now know that, given optimum conditions, vigorous and spreading varieties such as Bramley's Seedlin and Beauty of Bath on Malling Nos. I and II (Broadleaf and Doucin) will in all probability fill 40 fee square, whilst varieties such as Cox's Orange Pippin and Worcester Pearmain will need at least ha that space. We now know that trees on these stocks are not the comparatively short lived " fillers thought to reach their peak of production at 20 years and to be uneconomic at 30. Even trees o the much more dwarfing Malling No. IX rootstock are still to be found at 25 years old under averag

* Address given at a Conference organized by the K.W.A.E.C. at Maidstone, November, 1944.

ood management making healthy growth and producing high quality fruit—though when closely anted and heavily cropped from the first they do successfully perform the function of true fillers. o-day we can predict with some confidence the relative behaviour of the chief commercial varieties pon standardized rootstocks under differing soil, cultural and nutritional conditions. If it be conomically desirable to " middle " our standard sweet cherries with plums, the grower now knows hat he should allow at least 40-48 feet for the cherries (on Mazzard F12/1) even if he carefully selected is plums on rootstocks suitable to the variety and reasonably quick cropping so as to yield a worthhile return in the first 12-14 years.

There is, however, more than one road to success in fruitgrowing. Whilst one grower in a given nvironment may be most successful in handling his Cox's Orange Pippin on No. II as dwarf pyramids, ft. 6 in. by 8 ft., another will make the best use of the material as bushes at 24 ft. square. Under ethods of extensive culture the distance of planting to-day is being adjusted to facilitate the use of odern spraying and cultivating machinery. Where once it was enough to visualize space for a man nd a hose pipe to work, it may now be necessary to provide for a mobile sprayer. Where once it as enough to allow for the movement of weed-killing horse hoes, it may now be necessary to provide or the growing and turning in of bulky cover crops. By contrast in successful intensive culture oot competition may actually play an important part.

Our knowledge of cross pollination has made strides since the day when Bramley and Beauty f Bath were selected as suitable stable mates! To-day the planting of the "triploid" Bramley nvolves not only the presence of a contemporaneously blossoming " diploid " variety, but of a second iploid to fertilize the pollinator! The question of how we plan our orchards to-day in relation to he optimum number, position and variety of pollinators is one which might well occupy a whole lay's discussion. For instance, if we regard the pollinator as a necessary but annoying evil and educe the varieties and number to a minimum, we have to consider whether our choice has fallen n one with biennial propensities or on one especially sensitive to low temperature injury. Again, n how many planting plans have permanent pollinators been provided, and in how many orchards nave they disappeared with the " fillers ".

If the apple and pear grower must think carefully over cross fertilization, how much more does he cherry and plum grower need to have at his elbow, when planning, Crane's twelve groups of sweet cherries and three classes of plums—together with their relative seasons of flowering. The combinaion can no longer be settled on the grower's fancy alone.

Our knowledge of the nutritional requirements of individual varieties—let alone kinds—of fruit would make the grower of to-day shudder at a plantation of Bramley and Bath, let alone the admixture of cherries, apples and pears. To combine a nitrogen loving green culinary apple with an early soft dessert which sells on its colour and is especially sensitive to an unbalanced nitrogen potash ratio is now unthinkable. To-day we even debate as to whether Worcester is really the ideal pollinator for Cox, because the former may lose colour and finish under the higher nitrogen requirements of the latter. No wonder the conflicting demands of the underplanted currants, gooseberries and strawberries upset the scheme as a whole and increased the growth but delayed the cropping of naturally tardy yielding varieties.

Again, how has our spray schedule of to-day upset the planting plans of the past, when the value and safety of " the lime and sulphur spray " was under discussion, chiefly as a winter or delayed dormant wash. The era of tar and petroleum oils and of four or five spring and summer lime-sulphurs had not arrived. Bramley was still the Scab resistant paragon and Beauty of Bath had had no opportunity of showing how temperamental she could be.

I must resist the temptation to compare the accepted commercial varieties of to-day and yesterday —when Bath was a " best seller ", Worcester was being judiciously watched as a " canker monger " and Cox was, in all but exceptional cases, a " crazy speculation ". " Awkward " Allington was considered a safer proposition on most soils. Our studies of the individual requirements of each variety as regards rootstock, pruning, spraying, manuring and other cultural treatments have completely changed the scene, and even 10 years ago, when reading a paper on this same subject, I visualized that before long Cox would be the apple for the masses and not reserved for the banqueting table.

As we stand on the threshold of a " new era " of fruit planting we have, in addition to these milestones in our knowledge, a number of helpful signposts pointing the way to a more considered planning of our orchards and our fruit industry. First, we have both fruitgrowers and nurserymen appreciating the value of schemes for the *certification of fruit plants* true to name and free from disease. These call for extension as our knowledge and the situation allow. Second, at least in the case of apples, we have an *agreed list of the principal commercial varieties* recommended for working and planting on a large scale during the immediate post-war years. This will help to reinforce the beneficial effects of the National Mark lists which did so much to reduce the host of non-commercial sorts in our orchards. Third, the preliminary results of the recent *Census of fruit orchards* have now

been placed at the Industry's disposal, so that we may for the first time get some approximate measure of the actual proportions of the chief kinds and varieties of fruit grown in this country, and of the stage of development of our orchards. With such data available we should be in a much better position to estimate crops, to measure the actual supply against the potential demand, and to plan our future plantings in relation to the Industry's actual needs.

Incidentally, when the Empire Fruit Conferences are renewed, the representatives of our industry should be able to present a much more coherent picture, and be able to lay a much stronger hand on the table.

Summary.—The lay out of a typical plantation of 32 years ago is considered in the light of modern knowledge, and the chief points to be borne in mind in planning the plantation of to-day emphasized.

A GUIDE TO THE USE OF FRUIT TREE ROOTSTOCKS*

By R. J. GARNER

By the intelligent use of the rootstocks now in circulation the tree raiser can produce trees to meet the various requirements of the individual grower, particularly as regards the type of fruitgrowing intended, the soil and other local conditions. The right choice of rootstocks for apples is not discussed in detail here, but outstanding characteristics which should guide the tree raiser when deciding the particular combination of rootstock and scion are given for easy reference.

Vegetatively raised rootstocks are recommended because they produce trees which can be relied upon to behave in certain definite ways in regard to compatibility with the scion, growth, cropping and disease resistance.

Well-graded seedling rootstocks from selected sources have their uses for the production of large apple trees and, in the absence of sufficient vegetatively propagated pear rootstocks, are the only suitable basis for the production of standard pear trees. Prior to the introduction of standardized vegetatively raised Mazzard stocks (known also as Geans or Gaskins) all sweet cherry trees were worked upon imported seedling mazzards or more often upon wilding mazzards collected from the woods, which were mainly suckers from the roots of seedling trees of varying age. These rootstocks for cherries have been found to produce large trees that vary comparatively little in size. There are in existence vegetatively propagated rootstocks such as the Mussels, Brompton, etc., for plums which could be used on a much wider scale, but the ready availability of seedling Myrobolan, St. Julien and Black Damas has discouraged the wider use of these more expensively raised rootstocks. It is essential to use selected standardized stocks for many varieties of plums, peaches and nectarines to avoid particular incompatibilities. Seedling rootstocks are, however, fairly safe for varieties that show a high degree of rootstock tolerance.

Rootstocks for Apples.—The vast majority of the vegetatively propagated rootstocks in use to-day are designated by number. For example, there is Malling II which is one of the "Doucin" rootstocks described by East Malling Research Station. The numeral "II" has no reference whatever to performance or desirability, but merely indicates that this was the second distinct type of rootstock described by the Research Station. An accepted system of numbering has the advantage of meaning the same to tree raisers throughout the world.

Of the existing eighteen so-called "doucin" or "paradise" rootstocks some seven were selected as the best available to provide a range of performance to cover all needs. An attempt was made to aid nurserymen by dividing these into four hard and fast groups, but subsequent experience has shown that any such grouping needs qualification at least as regards soils and varieties.

Group (*a*) **Very Dwarf.** *Malling IX (Jaune de Metz).*—This is the only rootstock for apples in commercial use which always produces a relatively small quick-cropping tree, but it cannot be recommended for trees which are to be grown under adverse conditions. Trees on Malling IX need good soil and careful farming. The roots are brittle and the tree therefore needs a good permanent stake, and the heavy crops borne on the young branches need support. Except on poor dry soils this rootstock is excellent for cordons, but is unsuitable for dwarf pyramid culture because of the need for firm staking. Bush trees on Malling IX are spaced 10 ft. to 15 ft. apart according to local conditions. Very weak varieties make little growth on this rootstock, otherwise it can be used for all varieties and has a special value for bringing shy fruiting scions into quick cropping.

Malling IX roots very readily on stools, and transplants very well. Production per acre is low because of the limited production of shoots on the stool. Generous dressings of organic manures are

* This article has been written for incorporation in the Ministry of Agriculture's forthcoming Bulletin on Fruit Tree Raising.

quired annually to keep the stoolbed in full production. Such manures should be supplemented y dressings of potash.

The rind of this rootstock is very thick but " runs " well and readily takes the bud. Maiden nd two-year trees transplant well but older trees are slow to recover after moving.

Group (*b*) **Semi-Dwarf.**—*Malling VII.*—Trees on this rootstock make ideal small bushes and his stock is the only one in commerce to-day that forms real semi-dwarf trees. Trees on Malling VII ave grown as vigorously as on Malling I in their early years, but have soon settled down and cropped eavily, filling the gap between Malling IX and Malling II. Malling VII should prove an excellent ootstock for both the fruitgrower and the amateur gardener, for it makes a well anchored medium o small bush tree which rapidly attains size and then crops heavily for its size. A spacing of 18 ft. part on medium soils seems suitable for most varieties.

In the nursery Malling VII throws few shoots on the stool but roots well. Production of root- ocks per acre is never high. This rootstock makes clean whippy growths, free of laterals or spines, uns well for budding and transplants well. It is susceptible under some conditions to infection by *Bacterium tumefaciens*, causing galls at the base of the rootstock, and buyers naturally object to alled trees though there is no evidence that galls of this nature have proved harmful in the plantation.

Malling IV (*Holstein Doucin*).—Trees on this stock grow as vigorously as on the vigorous Malling XVI in the early years, then crop heavily and settle down into medium sized bush trees. Its chief drawback is its poor anchorage ; it leans over badly on all soils on which it has been seen in this country.

In the nursery Malling IV has behaved indifferently. It roots very well but is weak on the stool. n situations of high moisture and nutrition it should prove more productive. In dry seasons stocks ined out for budding do not run well and for this reason they should be budded at the optimum time. M.IV was widely propagated and used on the continent, but was only too often sold as M.IX (Jaune le Metz) on account of the yellowish colour of the wood.

Group (*c*) **Vigorous.**—*Malling II* (*Doucin*).—This is the most commonly used rootstock for bush rees ; probably 75 per cent. of bush trees in the British Isles are grown on this reliable rootstock. If growers were restricted to the use of one rootstock, Malling II would be a wise choice. It is com- paratively well-anchored and behaves satisfactorily in widely differing soils. Trees on Malling II crop early in their lives but not so early as those on Malling IX. In situations where trees on M.IX need spacing at 12 ft., trees on II may need 24 ft. Strong growing varieties make large permanent trees on Malling II on most normal fruit soils, but for large permanent trees of weak varieties, especially on poorer soils, stronger rootstocks should be used. Malling II is excellent for cordons on soils which do not induce strong growth ; it is considered an ideal rootstock for dwarf pyramids in the majority of situations and is good for espalier and other trained trees. It is very good for trees which are to be grown in pots.

Malling II is usually very vigorous in the stoolbed and good rooting is usually delayed until the stool is well established, when the very many shoots which are produced cause a decrease in vigour and an increase in rooting. This condition can be hastened by withholding nitrogenous manures but, as with all stool and layer beds, the available potash in the soil should be maintained at a high level by small annual dressings of from one to two cwt. per acre of sulphate of potash or its equivalent. When the stoolbed is in full production the output is very high because of the large quantity of shoots produced.

This rootstock takes the bud well and produces strong maiden trees which lift with good roots.

Malling I (*English Broadleaf*).—This rootstock has become less popular in recent years since it has proved to be more sensitive to environmental and varietal conditions than was at first apparent. It usually does better on moist soils than on dry and Cox's Orange Pippin on the drier soils makes an unthrifty tree.

Malling I roots exceptionally profusely on stools. When established the vigour diminishes quite rapidly and, though heavy manuring is not always necessary for the first three or four years, growth should be carefully noted and the manurial programme adjusted in good time before weak growth decreases output.

Very many fibrous roots are produced on the earthed shoots, and this stock is well known in nurseries for its good transplanting.

It seems likely that for general purposes this rootstock will further decrease in popularity.

Malling XIII.—This rootstock has not generally maintained its early promise of vigour and it is doubtful if it should be considered as suitable for large trees, for it probably comes into the group intended for medium-sized trees. It is not recommended, but, even so, seems preferable to indiscriminate seedlings because of its greater uniformity. It is surface rooting and this probably accounts for its good behaviour in " wet " soils.

The popularity of Malling XIII arose from the fact that it is easily raised. Rooting is profuse

and shoot production most vigorous and prolific. In some quarters there has been difficulty in getting a good bud-take, but in general this rootstock exhibits no difficulties in the nursery. However, its value must be judged by its performance when planted out for fruit production and this definitely falls short of other available rootstocks.

Malling V.—This rootstock has been frequently sold as Malling II and produces a similar tree under most conditions. The crop is, however, poor and the trees are specially susceptible to marginal leaf scorch so that this stock is not recommended. The variety Cox's Orange Pippin performs better on this rootstock than other varieties tested on it.

Group (*d*) Very vigorous.—*Malling XVI (Ketziner Ideal).*—At present this rootstock is the most readily available of the rootstocks intended for the really large well-anchored trees. On the poorer soils it makes excellent medium-sized bush trees and, in spite of its inherent vigour, crops comparatively early in its life. Trees on Malling XVI are normally spaced at 30 ft. to 40 ft. apart, but, with weak varieties and on really poor soils, 24 ft. may not be too close.

In the nursery it is productive on the stool and transplants well. It is very slow to begin growth in the spring and, like other vigorous rootstocks keeps growing through the autumn. The chief drawback to Malling XVI in the nursery is its great susceptibility to "Woolly Aphis", which, once firmly established in a stoolbed, is very difficult, or impossible, to eradicate.

Maidens on this rootstock are not invariably of large size, often being outstripped by trees on Malling II, but once established in the plantation M.XVI quickly demonstrates its vigorous character.

Malling XII.—On certain poor sandy soils Malling XII has given medium sized trees which have cropped fairly early in life, but on average soils growth is super-vigorous and cropping is much delayed. There has been some evidence that this deep rooted, superbly anchored rootstock is suitable in climates of abundant sunshine, where fruit-bud formation is at a high level, but for general use in this country it unduly delays cropping.

Malling XII is shy-rooting on the stool, especially when newly established. It transplants rather badly, probably owing to absence of fibrous roots, and is generally considered a "poor starter" when lined out. In spite of this, those that do get away at all soon make large healthy trees.

Malling Crab C.—The fruitgrower is much attracted by the good performance of trees on this rootstock. It is superbly anchored, grows very vigorously and yet crops reasonably early in its life. If it were more amenable in the nursery it would be the ideal vigorous stock from all points of view. It roots poorly by the usual standards and is somewhat lacking in transplanting qualities, in the form of one year layers, unless lined out at the optimum time.

The excellent behaviour of trees on Crab C has stimulated research into its propagation and it now seems that the better way to raise it is by root-cuttings, taken from maiden or two-year trees at lifting time. Plants produced from root-cuttings, moreover, are likely to transplant somewhat better than sparsely rooted shoots from stools or layers.

Seedling Stocks.—So far the supply of vegetatively raised rootstocks for very vigorous trees has not met the demand and seedlings are used to fill the gap. In the past the seed for raising seedlings came from the cider mills, but modern machinery damages the seed and renders it useless. Nowadays the main source for seed in bulk is the canning and apple-ring industry in the United States, and it has been found that the seed of the limited number of varieties used for these purposes gives less variable results than seed from many mixed varieties. The seed of "triploid" varieties, such as Bramley, should not be used as such seed is most variable. Careful grading of seedlings in the nursery tends to reduce variability and when combined with the use of seed from selected parents results in a product of some uniformity.

Rootstocks for Pears.—For medium sized and small trees.—Pears are peculiar in that the vast majority are grown upon the Quince, one of its weaker-growing relatives. When pears are worked on pear the majority make very large trees that are slow to crop and, when they do, bear smaller and greener fruit, at least for a time.

There are at present only three standardized quinces in circulation that can be considered as suitable rootstocks for pears. They are Malling Quince A (sometimes termed "Angers"), Malling Quince B (sometimes termed "Common Quince"), and Malling Quince C. All three quinces transplant well and take the bud perfectly, often giving close on 100 per cent. stand of maiden trees. A number of pears are not reliable when worked direct on Quince and these should be double-worked by grafting as detailed in the Station's Annual Report for 1943.

Malling Quince A.—This is a good general purpose rootstock for bush and smaller trees. Attempts are sometimes made to grow standard trees on this stock, but the anchorage of the quince roots is usually insufficient and, except in the most favoured situations, it should not be tried.

Confined to one rootstock the choice should be Malling Quince A; it maintains vigour whilst cropping and behaves well in the nursery, where it is highly productive on stools and is not subject to disease.

Malling Quince B.—This rootstock behaves in much the same way as Malling A in both vigour and cropping.

Malling Quince C.—Malling C usually produces a tree which grows as vigorously as Malling A until it crops, when it falls behind A in tree size.

Trees on C have cropped heavily and comparatively early in their lives, even varieties such as Doyenné du Comice, Beurré Hardy and Pitmaston Duchess. It is a useful rootstock for shy-cropping varieties and for small garden trees, and is admirable for cordons.

In the nursery it is weaker than A or B on the stool and, though prolific, its lack of vigour lowers its productivity.

Another trouble is that this quince, both on the stool and when lined out, suffers from Leaf Blight (*Entomosporium maculatum*) if not protected by a spray of Bordeaux mixture. However, it grows a good maiden tree equal in size to maidens on A or B, but a number of varieties frequently have a "blistered bark" when two years old, which may be so severe that a few of the trees die, the others recover normal bark after a few seasons.

For large trees.—Layered pear rootstocks have not so far proved easy to produce economically in sufficient quantity. The most hopeful method of vegetative propagation is by root-cuttings taken from maiden or two-year trees lifted from the nursery. Large trees, usually for orcharding, are therefore worked on pear rootstocks raised from seed. Such seed as has been obtained in the past has given seedlings that were very variable both in their compatibility with, and in their effect upon, different scion varieties. To-day the prime source of seed is from the canning factories of America, where Bartlett is the only variety used, and the seed from this one variety is fairly uniform.

Rootstocks for Plums and allied fruits.—Certain rootstocks used for plums also serve for peaches, nectarines and apricots in this country, but in other countries peach, apricot and almond rootstocks are also used. The right choice of stone fruit rootstocks is essential because of the numerous forms of incompatibility, and their identification and purity is obviously important. In the worst cases the bud take is very low, the few that grow dying before the end of the year. If all unsuitable combinations of stock and scion died quickly, the ultimate loss to the fruitgrower would be comparatively small, but unfortunately many grow more or less normally until they have been some years in their permanent position and only then become stunted and unprofitable or a complete loss by breakage at the union.

There are a few plum stocks that so far appear to be "fool proof" from the compatibility viewpoint, the chief are Brompton, the true Common Mussel, Malling Damas C, Malling St. Julien A, and Pershore (Yellow Egg).

Compatibility is not, however, the whole story, for each of these five affect the scion variety differently, in regard to vigour and cropping, in any one situation. Other rootstocks which are valued for commercial use, but which exhibit certain incompatibilities, are Common Plum, Malling Myrobolan B and Marianna. It is clear then that great care should be taken to arrange suitable combinations of rootstock and scion. A number of suitable combinations are shown below in the table.

There is not the same range of vigour-inducing qualities amongst the plum rootstocks, now in circulation, as there is amongst apples; no really dwarfing plum rootstocks have come into use. Brompton and Myrobolan B are the only rootstocks in the list which consistently make large trees, the remainder make trees of medium size.

Myrobolan B (*Malling selection*).—Myrobolan B has consistently proved suitable for the production of large trees and, though it delays cropping slightly, it very soon catches up and passes the production of trees on more dwarfing stocks. It is excellent for heavy cropping varieties and for damsons and bullaces, but is useless for peaches, nectarines and the plums Oullins Golden Gage and Count d'Althann's Gage. In general, shy cropping varieties, such as the high quality gage plums, should not be worked on this stock, for, even if compatible, cropping is likely to be delayed.

Myrobolan B behaves well in the nursery where, besides rooting well when layered, it also comes readily from hardwood cuttings. Small stocks quickly attain size and readily take the bud.

Brompton.—This rootstock is compatible with all varieties tried upon it and makes large healthy trees. It is splendid for peaches and nectarines and grows apricots well, though some may consider it too vigorous for the last. It generally exhibits little tendency to suckering; this habit is a drawback with many rootstocks that equal it in wide compatibility.

It is more difficult to propagate than Myrobolan B and Common Plum, being rather similar to Common Mussel in this respect. It "runs" well, even in adverse seasons and invariably shows a good take.

With wider realization of Brompton's excellent qualities it is likely to come into more general use.

Damas C (*Malling selection*).—This is similar to St. Julien A in its wide compatibility and its behaviour in the nursery. Trees on Damas C have been somewhat more vigorous than medium.

It resembles Common Mussel in its tendency to go dry in some budding seasons but it is more readily propagated on the layer.

Common Mussel.—The chief merit of this rootstock is its seemingly universal compatibility, and for this reason alone it is welcomed in the nursery, where it is used for peaches, nectarines, apricots, ornamentals and all kinds of plum; but it has proved disappointing in the plantation. Under some conditions the trees have lost vigour quite early in life, and the fruit has not maintained size. It suckers badly and many plum varieties show leaf scorch symptoms on certain soils upon this rootstock.

In the nursery the "spiny" growth of Common Mussel entails a considerable amount of trimming and it tends to "dry out" in the budding season. It propagates readily by root-cuttings but does not root very readily on the layer.

Marianna.—Where this rootstock is compatible with the scion, as it is with Victoria, Rivers' Early Prolific, Purple Egg, Laxton's Utility and others, it has behaved exceptionally well in producing

PLUM ROOTSTOCKS AND THEIR USES.

Some suggested combinations of rootstock and scion which appear suitable and compatible.

Scion Varieties.	Myrobolan B.	Brompton.	Damas C.	Common Mussel.	Marianna.	Pershore.	St. Julien A.	Common Plum.
Belle de Louvain		×		×	×			
Bullaces	×							
Bush (Kent)	×							
Cambridge Gage (see Gage Plums)	—	—	—	—	—	—	—	—
Cherry Plum	×							
Czar	×	×		○				
Damsons	×							
Gage Plums in general		×	×	○			○	○
Giant Prune	×	×		○	×			
Green Gage (see Gage Plums)	—	—	—	—	—	—	—	—
Monarch		×		○		○		○
Myrobolan (see Cherry Plum)	—	—	—	—	—	—	—	—
Oullins Golden Gage		×	×				○	○
Pershore Egg (see Yellow Egg)	—	—	—	—	—	—	—	—
Pond's Seedling	×	×		○		○		
President	×	×		○				
Purple Egg	×				×			○
Purple Pershore (see Purple Egg)	—	—	—	—	—	—	—	—
Rivers' Early Prolific	×	×		○	×			○
Utility (Laxton's)	×			○	×			○
Victoria	×	×	×	○	×	○	○	○
Warwickshire Drooper	×	×		○				
Yellow Egg (Pershore)	×	×			×	○		○
Apricots		×	×	×			○	
Nectarines		×	×	×			○	
Peaches		×	×	×			○	

×=Combinations for large to medium trees.
○=Combinations for medium to small trees.

medium to vigorous trees which have carried really heavy crops without losing size in the individual fruits. It has strong likes and dislikes, being incompatible in varying degree with Czar, President, Oullins Golden Gage, damsons and peaches and should be used with caution. It has the merit of suckering very little in the plantation.

Its attraction in the nursery is its property of rooting very readily from hardwood cuttings, probably the most convenient method of propagation, but it sometimes behaves badly when lined out for it is one of the quickest to tighten its bark in a dry season.

Pershore.—For the production of small trees, which come into cropping very early and carry heavy crops, this is the rootstock. Unfortunately it is so difficult to propagate in the nursery that it must be regarded as too costly for general use. It takes the bud well and has proved compatible with all varieties of plum and peach tried upon it.

Commercial Pershore rootstocks are obtained as suckers from fruiting plantations and are often mixed with suckers from neighbouring trees on other rootstocks or with seedlings which have become established there. In consequence such sources are suspect and should be resorted to with considerable caution.

St. Julien A (*Malling selection*).—This rootstock, selected from a heterogeneous collection of seedlings is compatible with all plums, peaches and apricots tried upon it and induces medium growth coupled with early cropping. It propagates considerably better than Common Mussel on the layer and is less branched and spiny. So far as can be seen at present there is no reason why this rootstock should not replace Common Mussel, except that it is not yet available in sufficient quantity for general use.

Common Plum.—This rootstock produces medium sized trees with early and heavy crops and shows a high percentage of natural recovery from Silver Leaf. It is excellent for gages, but shows definite incompatibilities with a number of varieties, including Czar, President, damsons and peaches.

Common Plum roots very readily when layered, its productivity on the layer being comparable to the ready rooting Myrobolan B.

Brussels.—This rootstock was probably the most widely used throughout Europe ten to fifteen years ago and must be mentioned. It is easy to propagate, but certain varieties are incompatible with it and it has been found to have a partially dwarfing effect on others and, with the exception of Victoria, these trees have given very poor crops. The trees on this stock have poor anchorage and sucker profusely. It appears to be a thoroughly undesirable stock.

Local rootstocks.—These nine varieties of rootstock by no means cover the range of vegetatively raised stocks and there are others that have some local or specialized use. In fact almost every district has its own local suckers. These include varieties such as Blaisdon Red, Cambridge Gage, Kent Bush, Warwickshire Drooper and Yellow Egg (Pershore) and bullaces and damsons. The Yellow Egg is an excellent rootstock and has already been mentioned. Blaisdon Red has proved to be a useful rootstock for some varieties, notably Monarch and Pond's Seedling. Warwickshire Drooper has also proved satisfactory when used as a rootstock. It often happens that the suckers taken from orchards do not turn out to be the variety that they were reputed to be and mixtures are frequent. Whilst it appears rather tempting to eliminate budding and grafting and raise plum trees on their own roots, even where the particular variety performs well on its own roots, it is well to remember from the tree raiser's point of view that once the stool bed is laid down, a fixed number of trees of that variety will be turned out every year, whether the variety is in demand or no. Furthermore, it has proved possible to increase the vigour and cropping of such varieties, by the standard rootstocks now commonly used and the extension of the use of " own root " varieties as rootstocks is not generally recommended.

Seedling Rootstocks.—In the past a large proportion of plum stocks used in this country were seedling Myrobolan, Black Damas and St. Julien imported fron the continent. Although there was a comparatively small variability in the size of trees on Myrobolan seedlings, a certain small proportion were incompatible. Seedlings of Black Damas and St. Julien varied much more, producing everything from very vigorous trees to comparatively dwarf ones, and included many incompatibles.

Rootstocks for Cherries.—There are three main kinds of cherry rootstocks to be considered. First, and most important, is the sweet cherry rootstock (*Prunus avium*) variously known as "Mazzard" or " Gaskin " or " Gean " according to locality. Then there is the " Mahaleb " (*Prunus Mahaleb*) which is passing out of use, as it has no particular merit other than the power to grow large young trees of acid varieties in a short time, many of which do not last long when set out. Lastly there is the acid cherry stock (*Prunus cerasus*) to which group the Morello, Kentish and Flemish culinary cherries belong. Attempts are still being made to find reliable acid cherry rootstocks for the production of small bush trees, but so far no reliable clones have been sufficiently tested with our popular sweet varieties to enable any definite recommendations to be made. The tree raiser is therefore confined, at present, to the use of sweet cherry rootstocks, all of which give rise to large, or very large, trees of sweet scion varieties and, at the same time, unite well with the acid varieties such as the Morello. Sweet cherry rootstocks have so far exhibited little sign of incompatibility with either the sweet or acid varieties in general use.

The sweet cherry rootstocks closely resemble the sweet scion varieties in shape of leaf, colour of wood and habit of growth and the utmost care is necessary in cherry tree raising to ensure that the growth comes from the bud or graft and does not arise below the intended union. Even an expert may be deceived by this, until the tree bears fruit, when the mistake is revealed to the grower and he realizes the loss he has incurred by planting an unworked rootstock.

These rootstocks are obtained in three main ways. First there are the seedling stocks, raised usually by specialists, and imported from the continent by home nurserymen, for growing on and working. Second come the so-called " wildings " which are dug in the woods of this country. These were originally seedlings which have suckered amongst the woodland and so are usually mixed groups of individuals. Third there are the selected vegetatively propagated clones, which have been found to possess special qualities of benefit to both the tree raiser and the grower. At present there are insufficient of these tested clones to fill all needs, and seedlings and wildings still have to be used.

The distribution of at least one clone, known as Malling 12/1, is now sufficiently wide for rapid multiplication and distribution to tree raisers in considerable quantity.

Malling 12/1 has produced vigorous and well-anchored trees that compare favourably with trees on seedlings and it has the advantage of producing uniform stems for high working, and is also excellent for bush trees of the acid varieties, where vigour is an advantage. It apparently has the valuable property of resisting Bacterial Canker, so that a stem of 12/1 does not readily succumb to this devastating disease. The leaf colour of 12/1 is very dark, and this aids in distinguishing it from the popular scion varieties.

Within the sweet cherry species there does not appear to be a very wide range of vigour, but there are indications that rootstocks of more moderate vigour may yet be isolated, tested and propagated for those desiring a tree of moderate size, possibly in bush form.

Sweet cherry rootstocks are readily propagated by layering and by root-cuttings made from young roots.

Summary.—The chief characteristics of rootstocks for apples, pears, cherries, plums, and allied stone fruits are given to guide tree raisers and growers in their choice of rootstocks.

PLANNING A CHERRY ORCHARD*

By N. H. GRUBB

CHERRIES are probably more restricted to certain soils than any other fruit. But they are more widely grown than cherry growers themselves usually realize. Besides Worcestershire and Kent, I have myself seen good cherry orchards in Berks., Bucks., Cornwall, Devon, Hereford, Herts., and Monmouth, and have corresponded with cherry growers in Essex, Lincolnshire, and Shropshire. Without much doubt they can be grown successfully in several other counties also.

Every county we have visited on cherry tours has its own local varieties, usually, but not always, distinct from those of other counties. Most of them, as one would expect, are of moderate quality at best ; but now and then one comes across a really good thing which seems to be unknown outside its own district. I remember meeting a cherry in Cornwall called " Bolium " ; the grower might well be proud of it, but regretted that a still better earlier one was already cleared ; he said " You should see our Rumbolium ! " The Lancashire gooseberry called " Rambullion " is evidently another form of the same name.

We all know that the tendency with most fruit is towards a reduction in the number of commercial varieties. This tendency is perhaps less marked among cherries than other fruits. Even apart from the local varieties which I have mentioned, there is a fairly wide choice of good commercial sorts, any of which are at least worth consideration. And this is fortunate, for sweet cherries are undoubtedly the most difficult fruits to plan satisfactorily. There are so many points to be considered,—cross pollination, time of blossoming, time of ripening, shape and ultimate size of tree, and in many districts susceptibility to disease, particularly Bacterial Canker. Let us see what we can make of these points.

I put pollination first, as it is probably the most vital. The workers at the John Innes Horticultural Institution, after hundreds of trials spread over many years, have shown how important it is. So far as we know yet, no sweet cherries will set fruit with their own pollen. But that is only part of the story. Mr. Crane has proved that there are eleven groups of varieties—he may yet find more—which will not set fruit with pollen from any other member of the same group. Perhaps one or two examples will show how vital it is that growers should use this new knowledge in planning their cherry orchards.

An orchard containing only Early Rivers, Knight's Early Black, Roundel, and the West Midland variety, Black Downton would fail to crop unless there were other cherries near by, although their blossoming periods overlap well enough. If there ever was any fruit in such an orchard, you would get a good succession for picking. But the trouble is, there never *would* be any fruit ; none of these varieties will set fruit with each other's pollen. The same thing would happen if you planted an orchard with Bigarreau de Schrecken, Frogmore, Waterloo, and Windsor, and no others ; or with Early Amber, Elton Heart, and Governor Wood. To get fruit we must plant together varieties belonging to different groups. Fortunately there are some fifteen varieties, called by Mr. Crane " universal donors ", which are compatible with all other varieties so far tested. The best known of these are probably Florence, Noble, Noir de Guben, and Bigarreau Gaucher, and they include the West Midlands varieties Black Oliver, Mumford, and Smoky Dunn. The moral of all this is : if

* Part of an address given at a Conference of Fruitgrowers at Worcester, December, 1944.

you are planting sweet cherries, do first of all get acquainted with the latest information Mr. Crane has published (John Innes Leaflet, No. 4).

Those who are planting acid cherries will find it much easier. Mr. Crane finds that the type of Morello he tested, and the variety usually grown as Kentish Red, will set a full crop with their own pollen. There are some acid varieties which will not do so, including a variety sometimes grown as Kentish Red ; but most of these are not commonly planted.

Now as to time of blossoming. Unfortunately some early blossoming sorts like Noir de Guben and Turkey Heart are midseason or late in ripening, and a rather late blossoming sort, Frogmore, is early ripening. We must plant together varieties that overlap in blossoming season with a good margin. A rather early blossoming sort like Early Rivers usually overlaps enough for pollination with midseason blossoming varieties like Waterloo ; and midseason varieties similarly overlap with rather late sorts, like Noble and Bradbourne Black. But early and late sorts rarely overlap enough for safety. They did in 1943, but that is unusual.

If spraying for Bacterial Canker becomes a routine operation, as it probably will in some districts, we may have to be rather careful in planting together only varieties that blossom about the same time. The spring spraying is done just before blossoming, and the nearer to blossoming time the better.

Time of ripening has to be considered for both picking and bird minding. Orchards with early, midseason, and late varieties indiscriminately mixed are always the worst for both jobs. It is far more convenient to have the early varieties at one side and later varieties at the other. Consider only ladder moving, for instance ; no one can fail to see how much time is saved if one doesn't have to carry ladders from end to end of the orchard several times.

But time of ripening is still more important in making sure that one can get the fruit picked without delay. Every cherry grower finds that he must " keep on top of his picking ", so that if one or two wet days come he won't get hopelessly behind. So in making our plan we must consider how many pickers are likely to be available; if the number is limited, we must also limit the number of trees that need picking at the same time. It is also important to get a good succession in picking, so that the pickers can be continuously employed, without gaps of several days when there is no fruit ready. In practice this merely means that if one has both early and late sorts, one must have some midseason sorts also.

These points must also be kept in mind when we are replanting places in the orchard where trees have died. Growers naturally like to try fresh varieties from time to time, and it is certainly a good plan ; but let us make as certain as possible that any fresh varieties we plant are not too far away in time of blossoming and ripening from the trees surrounding them.

Next, as to shape and size of tree. Here again varieties differ very much, from the tiny trees produced by such little known varieties as Bloor's Heart and Reine Hortense, to the immense trees often seen of Kent Bigarreau, Caroon and many others. And though most varieties make a fairly wide spreading tree, we have the contrast between some of the Dukes, almost like Lombardy poplars, and the low wide spreading trees of Early Lyons, Early Amber and Governor Wood. Obviously the best use will be made of the space if a more or less upright variety, like Schrecken or Roundel, or a compact tree, like Waterloo, is planted diagonally between trees of a large growing spreading sort.

The actual distance of planting depends much on local conditions. As a rule, the richer and deeper the soil the greater should be the planting distance ; but even here there are exceptions. On some of the very best brick-earths in North Kent the trees are always small, apparently because they crop so heavily and regularly that they never get the chance to grow large. Our soil at East Malling is not one of the best, yet 30 feet for standard cherries is clearly too close, and we are now planting at 36. On better soils we should suggest 40 to 48. It might I think be said that those who are planting cherries in unfamiliar conditions usually plant too close.

Something more must be said about diseases. I am not a pathologist, but it has fallen to me to keep most of the records of the East Malling cherry variety collection, and consequently there are a few things I can safely say.

Except for Bacterial Canker, cherries are perhaps freer from diseases and pests than most fruits. Black fly can make a mess of them, especially in the nursery, I know ; and Brown Rot Blossom Wilt is usually a problem in Morellos, and can do serious damage to many other cherries also. But visits to cherry orchards in several counties have shown that Bacterial Canker is a more widespread trouble than any other disease. Even where it is not a serious problem, careful search almost always shows that it is present, at least on such susceptible varieties as Napoleon.

Wherever the disease is bad, it is almost impossible to grow the more susceptible varieties. We know of several places where it is very definitely worse than at East Malling ; yet there is quite a list of varieties in our collection of which we have never been able to keep a tree alive to its cropping age. It seems to be a fact that certain varieties may be susceptible in one place and resistant in another ;

or perhaps their resistance varies with their age. But there do seem to be certain varieties which are always resistant, and others which are always susceptible. Our experience at East Malling, which is certainly corroborated by the experience of a good many growers, shows that these are generally resistant: Black Tartarian "E" (the very large, long, "bumpy" fruited variety), various Caroons (there are many), Early Amber, Early Lyons (Jaboulay), Emperor Francis, Frogmore Early, Governor Wood, Knight's Early Black, Noble, Noir de Guben, Nutberry Black, Old Black Heart, Rodmersham Seedling, Roundel, Turkey Heart, Waterloo and Windsor; and, of the West Midlands varieties Black Elton, Black Oliver, and Smoky Dunn. So there is a list of 20 varieties which are worth considering where the disease is known to be bad. Even that list does not include Early Rivers, Bigarreau de Schrecken, Bigarreau Gaucher, Kent Bigarreau, and several others which often remain quite healthy, even where more susceptible varieties are useless.

In conclusion I must just mention the two new varieties recently named at the John Innes Institution—Merton Heart and Merton Bigarreau. I have seen these growing healthily and cropping well in a rather unsuitable soil at Kent Farm Institute. It is perhaps doubtful if trees are yet obtainable, but scion wood may be. They are both very well worth trying.

Summary.—In planning a sweet cherry orchard, efficient cross pollination, time of blossoming, time of ripening, susceptibility to disease, shape and ultimate size of tree should be taken into consideration when selecting varieties.

ACCELERATING ROOTSTOCK RESEARCH*

By A. BERYL BEAKBANE and ELEANOR C. THOMPSON

APPLE, pear, plum, cherry and peach varieties are usually grown on the roots of another plant which is known as the rootstock. Rootstocks grown from seed have variable effects, especially on the size and age of cropping of the tree, but some of them have been selected from time to time by fruitgrowers and nurserymen and their particular characteristics perpetuated by multiplying them vegetatively. No one, however, knew exactly the effect of any of these rootstocks until those in commercial use were classified and tested at the East Malling Research Station, some 30 years ago.

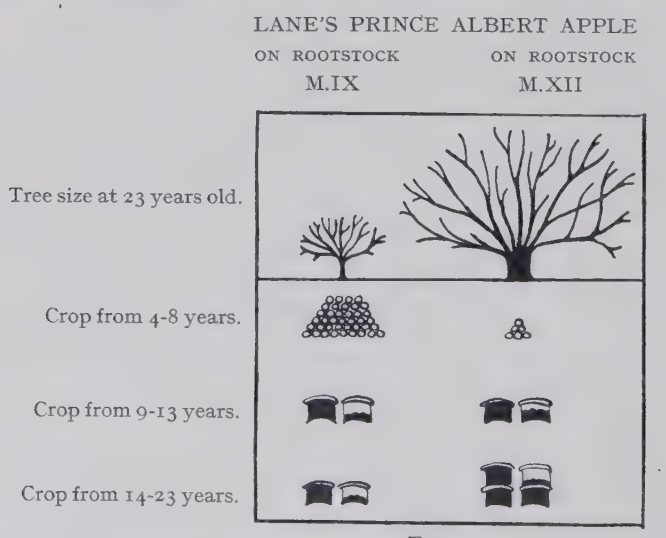

LANE'S PRINCE ALBERT APPLE
ON ROOTSTOCK M.IX
ON ROOTSTOCK M.XII
Tree size at 23 years old.
Crop from 4-8 years.
Crop from 9-13 years.
Crop from 14-23 years.

FIG. 1.
Vigour and cropping of Lane's Prince Albert apple as influenced by a dwarfing and by a vigorous rootstock.

It was shown, for example, that an apple variety such as Lane's Prince Albert, budded on the rootstock called Malling XII, will grow into a large tree that does not carry much fruit for ten or fifteen years, whereas on the rootstock Malling IX, it will make a small tree that begins to crop in the third or fourth year. (See Fig. 1.) Differences of this nature are important to all fruitgrowers. There is a demand to-day for a healthy, small, quick-cropping tree, for it is needed both by the

* Reproduced by permission from *Science News Service.*

commercial fruitgrower who wants an early return on capital invested and also by the gardener who wishes to make the best use of the limited space in his garden. While Malling IX satisfies the need for a dwarfing rootstock for apples, no equally suitable dwarfing rootstocks have been discovered for pears, plums, cherries, peaches and apricots. It is, however, believed that such rootstocks could be produced by plant breeding.

Although it is easy enough to raise new rootstocks from seed, the testing of their potentialities, first in the nursery and then in the field, takes many years and much land. A search has been made, therefore, for a method of speeding up this testing, and recent work at East Malling promises to assist by making it possible to forecast the influence, on vigour and age of bearing of the scion of any seedling rootstock while it is still quite young.

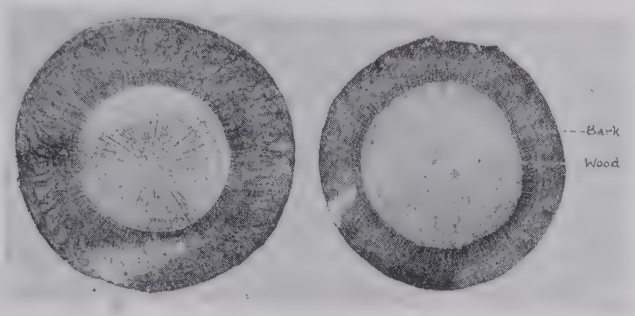
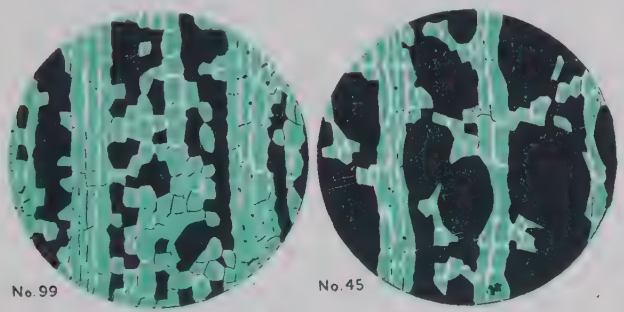


FIG. 2.

Photo-micrographs of transverse sections of the roots of apple rootstocks. Note the thick bark in Malling IX (dwarfing) as compared with Malling XII (vigorous).



Key Green = Living Tissue (Parenchyma and Rays).
Black = Dead Tissue (Vessels and Fibres).

FIG. 3.

Photo-micrographs of the wood of two seedling apple rootstocks, coloured to show the relative amounts of living and dead tissue. Note the large amount of living tissue present in the wood of No. 99 (dwarfing) as compared with No. 45 (vigorous).

A detailed examination of transverse sections of roots from a wide range of classified rootstocks has revealed a close correlation between the internal structure of the root and the influence of the rootstock on the vigour and cropping of the variety grown on it. In general, rootstocks, with a high proportion of living cells in the root will induce dwarfing and youthful cropping. The root bark, which is largely composed of living tissue, has been found to vary in apples from 20 to 75 per cent. of the whole root tissue. (See Fig. 2.) Much of the tissue in the wood is dead and lignified or "woody" and provides the strengthening material which gives the root its toughness, but the percentage of living tissue may sometimes be very high even in the wood. (See Fig. 3.) An apple rootstock with a relatively thick bark and a high proportion of living tissue in the wood is likely to be very dwarfing in its effect and to induce the tree to crop when quite young, while a rootstock with a thin bark and a wood chiefly composed of dead, lignified tissue will usually produce a large tree which will not bear fruit for many years. Many intermediate combinations of structure correlated with intermediate vigour and cropping are found, and a start has already been made to sort through

batches of seedlings amongst which it is hoped to find rootstocks that fill the needs of fruitgrowers and amateurs more adequately than those available to-day.

Summary.—There is a close correlation between the structure of apple rootstock roots and the vigour of the varieties worked on them. This offers a means of hastening the testing of rootstock varieties.

RECOGNITION OF "RUBBERY" CONDITION IN LORD LAMBOURNE AND SOME OTHER APPLE VARIETIES

By A. BERYL BEAKBANE and ELEANOR C. THOMPSON

SEVERAL trees of the apple variety Lord Lambourne affected by the disorders now known as "Rubbery Wood" and "Chat Fruit" were observed by workers at the Station some years ago, viz. "Rubbery Wood" in Kent in 1935 and "Chat Fruit" in Norfolk in 1941. These phenomena were referred to geneticists on the assumption that they were probably bud mutations.

During the last few years many "Rubbery" and "Chat Fruited" Lord Lambourne trees have been noted in various parts of the country (Wallace, Swarbrick and Ogilvie (1944); and Crane (1944)). More recently still, in 1945, we have observed "Rubbery" trees of three other apple varieties, namely James Grieve, Miller's Seedling, and Dartmouth Crab. There is some indication that this disorder may spread from plant to plant, since the affected trees of Miller's Seedling, which were apparently healthy when planted, were growing near Lord Lambourne trees known to be "Rubbery". The

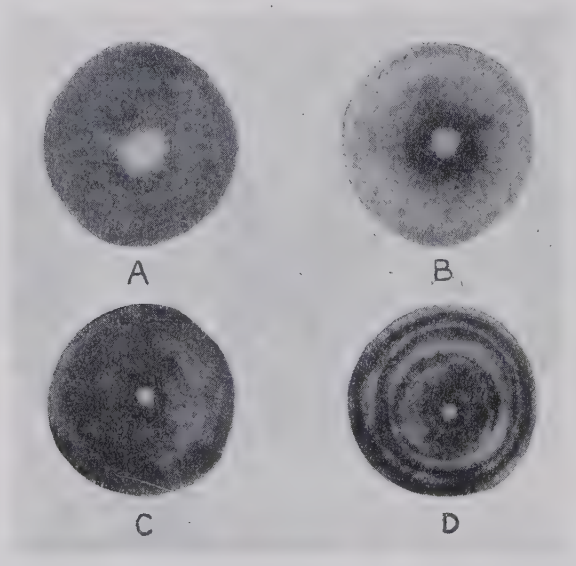


FIG. 1.

Cross sections of the wood of maiden trees of Lord Lambourne (A and B) and branches of Miller's Seedling (C and D) stained with the test solution as given in the text.

Note the pale areas in the "Rubbery" specimens B and D as compared with the more even colouring of the normal wood in A and C.

(A and B ×3·5, C and D ×1·5 approx.).

scion wood from which the Dartmouth Crab tree was produced was taken from a tree growing in proximity to "Rubbery" Lord Lambourne trees.

We have found that the flexibility of "Rubbery Wood" in Lord Lambourne and the three other apple varieties given above is due to a lack of the strengthening material (lignin) normally present in the walls of the fibres in mature wood. A study of fruit tree stems in general has shown, however, that several different types of structure may be associated with extreme flexibility of the stem, and that flexibility in itself is no certain proof of the presence of the particular structural abnormality found in trees affected by the disorder known as "Rubbery Wood". An equally flexible

condition in the stems of some other apple and pear varieties and in some apple rootstocks was found to be due either to an unusually large pith, or to a higher proportion of living cells in the wood than is commonly found in these stems.

Although the cause of the " Rubbery Wood " disorder has not yet been established, it has been suggested that it may be due to a virus disease. The lack of lignin in the fibre walls in such large areas of the " Rubbery " wood suggests an unbalanced metabolism, such as might be due to a disease or to mineral deficiency. There was no evidence of a diseased condition in the other equally flexible apple and pear stems examined, where the flexibility was due to different causes.

The various types of flexibility may readily be distinguished by microscopic examination. It also seems possible to distinguish between " Rubbery Wood " and other very flexible apple and pear stems by a simple colour reaction. When a cross section of normal wood about $\frac{1}{4}$ inch thick is soaked in the test solution described below, it becomes red all over after about 5 minutes, whereas white areas are clearly visible in a similarly treated cross section from a " Rubbery " stem.

The ingredients required are solid phloroglucinol and concentrated hydrochloric acid, both obtainable at any chemist's shop. One gram of solid phloroglucinol and 200 c.c. of concentrated hydrochloric acid are sufficient to carry out many tests. The test solution is prepared by making a saturated solution of the phloroglucinol in water and mixing two parts of this solution with one part of concentrated hydrochloric acid ; this can be done by adding as much phloroglucinol as will go on a sixpence to about two-thirds of an eggcupful of water and adding to this one-third of an eggcupful of concentrated hydrochloric acid. This solution may be kept for a few days, but is better freshly mixed, and it should be made up in a bottle with a well-fitting cork or stopper, taking care to avoid getting the strong acid on hands or clothes. The mixture should be shaken before use. The method of testing is as follows :

(1) Cut off a cross section of the stem about $\frac{1}{4}$ inch thick. Remove the bark with the thumb nail, taking care to separate the bark from the wood, but not to damage the young tender wood. Place the slice in a glass dish and cover completely with the solution.

(2) Note the colour reaction after about 5 minutes. Normal wood becomes red all over, while " Rubbery " wood shows white areas. (See Fig. 1.)

When examining orchard trees test wood of two or more years old, since the abnormality cannot be readily detected in thin one-year-old lateral shoots without the aid of a microscope. If this colour test is used as a means of surveying nurseries of maiden trees for " Rubbery Wood ", sample maidens should be tested at the base of the scion shoot since the symptoms are much more difficult to detect in the tip.

Summary.—A staining method is described for detecting the " Rubbery Wood " disorder in Lord Lambourne and certain other varieties of apple.

References.

CRANE, M. B. (1944). " The mystery of Lord Lambourne." *The Grower*, vol. 22, no. 53, p. 10.

WALLACE, T., SWARBRICK, T. and OGILVIE, L. (1944). " Some new troubles in apples with special reference to the variety Lord Lambourne." *The Grower*, vol. 22, no. 49, p. 12.

THE PLANTING AND MAINTENANCE OF RASPBERRY CANE NURSERIES

By N. H. GRUBB and R. V. HARRIS

1. Why Cane Nurseries ? Success in raspberry culture depends first of all on a supply of healthy well-rooted planting canes, true to name and free from " rogue " varieties and chance seedlings. " Health " means chiefly freedom from those diseases—Mosaic and Leaf Curl—caused by viruses, which cannot be eliminated except by the removal (" roguing ") of the infected plants.

The bulk of canes planted by commercial growers still come, as they always have done, from cropping plantations ; canes are sometimes taken for sale even from old plantations when they are grubbed. For various reasons, however, a cropping plantation is unsatisfactory as a source of planting canes. Owing to their slow degeneration, and their frequently inconspicuous symptoms, virus-infected plants are easily overlooked, and in any case the " roguing " of such plants after the first year of the plantation is not usually worth while. But if planting canes are taken from an unrogued plantation, the spread of virus diseases (and rogue varieties, if present) that have already occurred will

mean that the new plantation starts from the point the old plantation has reached ; it will often be impossible by any amount of roguing to restore it to good condition. This is now believed to be the chief reason for the degeneration and disappearance of many old and formerly valuable varieties. Anyone who has watched the behaviour of the variety Lloyd George during the last fifteen years cannot fail to see that some at least of our newer varieties are following the same course.

This difficulty can be avoided by establishing cane nurseries (or spawn beds) designed solely for the propagation of the best planting canes. From such nurseries all the new (first year) cane is harvested annually, and fruiting (second year) cane is thus completely excluded, with the following advantages :

(1) A greatly increased output of well-rooted planting cane per acre.

(2) Easier and more efficient inspection and roguing for purity and freedom from diseases.

(3) Each harvest of planting canes is ensured free from important fungus diseases, e.g. Cane Blight and Cane Spot.

(4) There is much less risk of the stock becoming mixed with self-sown seedlings.

2. Variety and Isolation.—For propagation purposes the treatment of individual raspberry varieties differs according to their differing capacity for displaying clear field symptoms of the virus diseases with which they may be infected ; and for this purpose they may be grouped roughly as follows :

Class 1.— *Virus "Sensitive"*.—Varieties which can be completely rogued for virus diseases. (Example : *Norfolk Giant.*)

Class 2.— *Virus "Tolerant"*.—Varieties which can only partially be rogued. (Example : *Lloyd George*) ; or have not yet been known to display any distinct symptoms of virus diseases. (Example : *Newburgh.*)

Class 1 ("**Sensitives**").—Norfolk Giant is the only widely grown commercial variety to-day known to be fully "*sensitive*", to which it adds another valuable quality, namely, a high degree of resistance under many conditions to infection with the Mosaic diseases. As a result new infections of Norfolk Giant occur very infrequently even in close proximity to powerful sources of infection, and can then promptly be detected and "rogued". Except in areas subject to Leaf Curl disease, there is therefore no necessity for any exceptional isolation of Norfolk Giant cane nurseries on health grounds, a minimum distance of 12 ft. from other normal plantations and 50 ft. from heavily diseased plantations being adequate. Norfolk Giant is thus an ideal variety for easy and efficient propagation, and is now eligible for certification by the Ministry of Agriculture and Fisheries and the Department of Agriculture for Scotland for health and purity of stock.

Class 2 ("**Tolerants**") comprises the great majority of present day named and new seedling varieties. These display their virus diseases incompletely or not at all, and it follows that cane nurseries of such varieties cannot be kept reasonably healthy simply by "roguing" them by field symptoms, but that the spread of those diseases which are not displayed (i.e. which are "carried") can only be countered by *isolating tested stock from all sources of infection*, i.e. *other raspberries.*

Cane nurseries of Lloyd George and other "tolerants" should therefore be situated as far as possible from a raspberry cropping area and from cane nurseries of other "tolerants", and it is thus advisable to concentrate on propagating one "tolerant" variety alone.* If more varieties than one are to be propagated, "sensitives" should be preferred, e.g. with Lloyd George propagate Norfolk Giant, rather than Newburgh.

3. Plant Material.—It is obviously vital to secure the truest and healthiest possible cane for starting a cane nursery. Of varieties eligible for official certification (at present Norfolk Giant only) cane from a certified source should be secured. If no certified cane is available, the proposed source of cane of virus-sensitive varieties should be inspected at a time when symptoms of virus diseases are showing, i.e. July to early September. But "tolerants" such as Lloyd George and Newburgh cannot be selected on the absence (or a reasonable minimum) of field symptoms alone, and failing any official special certificate (based on the propagation of tested stocks in adequate isolation) expert advice should be taken on suitable sources of canes of all such varieties.

Planting canes should also be reasonably free from fungus diseases. This point is fundamentally much less important than maximum freedom from virus diseases, and although canes heavily infected with Cane Blight and Cane Spot, especially the former, should generally not be used, the cane nursery method, as already mentioned, tends automatically to eliminate all fungus infection. Where the use of such cane is unavoidable, freshly planted canes should be cut down in the early spring to the lowest good bud, and as soon as the new canes are a few inches high, in May or early June, should be cut away entirely. This will at least reduce the infection of the new canes during the first year of the nursery to a minimum.

* The few current strains of Lloyd George that approach the original stock in vigour have been propagated at least one mile from other considerable raspberry plantations.

The size-grade of canes for planting is less important than plenty of roots and careful handling between digging and planting. Small canes, well rooted, even if only a few inches high, generally grow better than large, poorly rooted canes. In very dry conditions, such as occurred in many parts of England in the spring and summer of 1944, large well-rooted canes sometimes grow better than similarly rooted small ones, presumably because they have more reserves to fall back on.

Severe drying of the roots between digging and planting reduces growth more than is usually realized. In dry weather in winter, canes carelessly heeled in, especially if they are in large bundles, may be very badly damaged by drying. Large bundles should always be untied and spread out before they are heeled in, and the roots well covered.

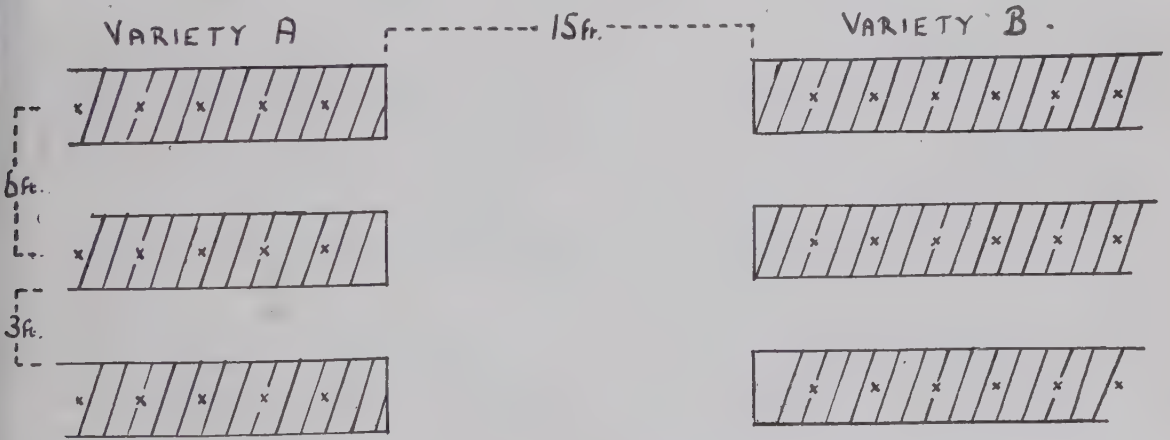
4. Soil and Situation.—Any soil that will produce a good fruiting plantation of raspberries can be relied on to give a good cane nursery. If the land is in good heart before planting there should be no need for heavy dressings of manures or fertilizers. Should growth subsequently become weak, dressings can then be applied during the winter without much difficulty.

But some caution is needed in choosing the soil for the purpose. Since it is necessary to use spades for digging the canes, a very stony soil is unsuitable, or in fact any soil into which it is difficult to drive a spade. Soil that is very foul with weeds, especially " water-grass " and lesser bindweed, must also be avoided. Keeping the crop clean is an expensive job; even annual weeds like " fat hen " and black nightshade are a disadvantage. It sometimes becomes necessary to pull such weeds by hand in order to make Mosaic roguing possible.

5. Planting Plan and Procedure.—Where suitable planting material is not very scarce, a distance of 6 ft. by 2 ft. is usually satisfactory. Scarce varieties, except where they are known to produce few canes, can usually be safely planted 2 ft. 6 ins. to 3 ft. apart in the row. (See Text Fig.) In the East Malling cane nursery even " Seedling E ", not a very prolific cane maker, has given a good cover when planted 3 ft. apart. But in many soils such varieties as Pyne's Royal, and to a less extent Preussen, will not do so ; even when planted at 1½ ft. the cover is seldom dense enough to keep weeds down.

A distance of less than 6 ft. between rows is usually undesirable, because of the need to keep a cultivated strip clear of canes for inspection and roguing. A solid block of Norfolk Giant is almost impossible to rogue ; even clear strips 3 ft. wide are apt to be almost closed by crossing canes, and can only be used when the foliage is dry.

Where more than one variety is grown in a single cane nursery, varieties must be separated by at least 15 feet. The tendency of the varieties to run into one another can be delayed by planting varieties in a continuation of the same rows, and not in rows side by side, thus :—



If more than one variety must be propagated in the same nursery, it is desirable, where possible, to arrange them so that those next to one another are readily distinguished, as (for instance) by the colour of the spines or canes, or by the presence or absence of downy hairs on the cane. This makes it fairly easy to remove mixtures if the varieties do eventually run together. Deep cross cultivation of the 15 ft. strips will also help.

Freshly planted canes should always be cut down some time before growth begins, but at least one good bud and preferably three buds should be left. It is a common experience that cutting down too low prevents many of the plants from growing. Over-deep planting should also be avoided. The topmost roots should be just below the surface and the soil trodden well around them.

6. First Year Maintenance.—Normal cultivation and hoeing, as for a newly planted fruiting plantation, is required. Intercropping with some crop that does not " draw " the ground severely may be practised, but must be regarded as undesirable except in very fertile soils.

Cane nurseries are conducted for the sole purpose of producing canes ; they are not allowed to fruit. The stubs of canes left after planting will usually produce some blossom and fruit and it is essential to prevent this fruit from ripening ; otherwise some of the seeds falling on the ground will eventually produce seedlings and the stock will become mixed. Where the growth of new canes is good, the old stub can be cut clean away with secateurs, before the fruit ripens ; but this must not be done until the new canes are several inches high. Where, as sometimes happens, new cane growth is delayed, it is advisable to de-blossom the flowering shoots, allowing as many leaves to remain as possible. With new and scarce varieties this is well worth while, wherever the new canes are not already growing vigorously.

7. First Year Harvesting.—A good crop of canes in the second and subsequent years depends on getting the soil well filled with roots large enough (say $\frac{1}{8}$ inch in diameter or larger) to produce new canes. Cane growth is usually more prolific if the roots are detached from the parent plant ; consequently it is desirable to dig out all the strong plants after one year's growth, leaving as many roots in the soil as possible. This may seem drastic treatment, but is proved by experience to be fully satisfactory. Weaker plants, where the new canes are not more than, say $1\frac{1}{2}$ to 2 ft. high, may not have a large enough root system to stand such treatment, and are best cut down level with the ground. (There is no need to leave even one bud to grow.) As it is desirable to leave as much root in the soil as possible, spades are used for digging, and are inserted 3 or 4 times round each plant so as to cut all the roots. Any small " spawn " from the plants can of course be dug separately.

All canes thus dug can be used for planting, and will usually grow well, even where their remaining roots are only an inch or two long. They are useful for " gapping up " where necessary. Gaps of 6 ft. or more, where plants have failed (but *not* where they have been removed with Mosaic), can be filled. This must be done while the plants are being dug ; otherwise the position of the gaps will not be obvious. Such " replants " must of course be treated in all respects like plants in a newly planted plantation.

8. Second Year Maintenance.—A cane nursery normally produces a good crop of canes in its second year. Most varieties, if allowed to grow unchecked, will fill the whole space between the rows with canes ; a strong spreading variety like Norfolk Giant, which by September may produce canes 6 ft. long or more, will make it almost impossible to get through for roguing. For this reason it is necessary to keep strips cultivated and clear of canes at least till the end of July, preferably later. Where rows are 6 ft. apart, the strips may be 3 ft. wide, leaving for each row a strip of 3 ft. producing canes. (See Text Figure.)

It is necessary, just as in the first year, to prevent any fruit from ripening. Any replanted plants will produce some blossom and fruit, but with many varieties the bulk comes on the tips of the new canes in the autumn. Varieties differ widely in their tendency to flower on the tips ; the only named variety which, so far as the writers know, never does so is Newburgh.

9. Second and Subsequent Harvests.—The canes are dug in the same way as the first year, except that *all* are dug, weak as well as strong. It is essential to remove every cane, even if only a few inches high ; any left will add to the work of fruit removal in the following year, and they may also act as sources of infection with fungus diseases, particularly Cane Spot.

10. Reversal of Cropping and Cultivated Strips.—Length of Life of Nursery.—After two or three crops of canes have been taken from the strips where the rows were planted, growth is apt to fall off in vigour. It is then a good plan to change over, taking crops of canes from the strips previously cultivated—now, of course, full of roots—and cultivating the strips where the rows were planted.* The length of life of a cane nursery will doubtless vary with circumstances. Where it is possible to keep the nursery reasonably free from perennial weed growth, it might perhaps extend to two or three such " changes over ". In land which is apt to become foul with weeds, from two to four crops of canes may be the economic limit.

Where weed growth is not a serious problem, but cane growth is too weak, it is quite practicable to give a dressing of dung in the winter. It is not necessary to leave this on the surface, and is in fact undesirable to do so wherever Raspberry Cane Midge is present. Shallow cultivation of the cropping strips in winter,—just deep enough to cover the dressing of dung,—does not appreciably interfere with cane growth in the following year.

11. Inspecting and Roguing.—This is the most fundamentally important operation in cane nurseries of both " Sensitive " and " Tolerant " varieties, although of only limited application and effectiveness for the latter. Even for such highly tolerant varieties as Newburgh an annual inspection

* This is the procedure under the Dominion Government certification scheme, Canada, where it is successfully practised.

r possible " degenerate " cane is advisable, and also, of course, for the occurrence of Raspberry ane Midge and Cane Blight to which the variety is particularly susceptible.

Roguing for disease and rogue varieties implies an aptitude for recognizing the often inconspicuous mptoms of virus diseases and for detecting varietal and seedling " rogues " ; this may require some aining, from horticultural advisers or other experts. " Getting one's eye in " for Mosaic and the istinguishing characters of the varieties under propagation is the main secret of success with cane urseries.

Generally the best time for roguing both for virus diseases and " rogues " occurs in July, and gain in September until cane-growth ceases and autumnal discoloration starts. A dull dry day hould be selected, as symptoms tend to be masked by direct sunlight or moisture on the foliage. The peration is best carried out by two persons one working on each side of a cane-row, together with he necessary labour for grubbing, carrying off and burning ; and if direct sunlight is unavoidable ne of the " roguers " should cast his shadow on the canes under inspection.

The most important roguing of a cane nursery is in July of its first year, i.e. before suckering as developed and when individual diseased plants and " rogues " can, therefore, be pulled up by hand. f possible a final inspection should be made in September, when any plants rogued should be carefully lug and as much root as possible removed. In subsequent years, at least one roguing should be made n July or September, but preferably in each of these months.

Since Mosaic diseases most commonly spread from plant to plant in a row, it is advisable with ertain varieties, e.g. Lloyd George, also to remove the immediate neighbours of the plants showing symptoms. With varieties highly resistant to infection, e.g. Norfolk Giant, this may not be necessary.

After the first year, when the rows are solid strips of cane, a patch should be cleared extending about 3 ft. on either side of the canes showing disease symptoms.

All rogued cane should be carried off the nursery without delay and burnt.

In view of the risk of renewed growth from roots of plants rogued after July of the first year, it is desirable to mark each gap with a stout stake driven well into the ground, and the area so marked should be kept free from canes by hoeing more than once in the following year. Unless there is a further outbreak of Mosaic nearby, the stakes may be removed after one year.

12. Productivity of Cane Nurseries.—The number of canes produced by an acre of nursery varies widely with soil, season and variety ; by actual count, it can vary from 25,000 to 150,000. Consequently little guidance can be given as to probable production ; it may be said that 25,000 is a low figure, and will often be exceeded.

Some varieties (e.g. Lloyd George) commonly produce branching canes ; where the branching occurs at or below ground level it becomes very difficult to make any reliable estimate of the number. In 1944 frost injury made the canes of some varieties at East Malling branch to an unusual extent. It might be thought that, since few canes were killed outright, the total number would not be appreciably reduced. But this is a mistake ; the denser shade produced by the many branches greatly reduced the growth of late " spawn ", which is usually a material factor in production. Estimates should, therefore, always be conservative. It may in some cases be wise even to reduce the apparent number of canes by more than half, at least until one has had some little experience of both local conditions and the varieties concerned.

Summary.—The reason why special cane nurseries for raspberries are needed are explained, and the planting, maintenance, roguing, harvesting and productivity of the nurseries described.

STRAWBERRY RUNNER SUPPLIES AND CERTIFICATES

By W. S. ROGERS

THE year 1945 is an important one for the strawberry industry. With the relaxation of regulations and the end of the war, a considerable increase in strawberry planting may be expected ; and, if the troubles of the period following 1918 are to be avoided, it is important that only the most healthy stocks should be used for planting, and that diseased stocks should be rigorously avoided. A review of the present position regarding certified stocks and runner supplies may therefore be helpful.

The Strawberry Nuclear Stocks Scheme.—This Scheme, under which East Malling Research Station, on behalf of the Ministry of Agriculture, supervised the large scale raising of tested clonal stocks of Royal Sovereign, Huxley and Oberschlesien strawberry plants, came to an end in the spring of 1945. By then the objects of the Scheme had been achieved, namely to supply the Industry with a nucleus of plants of the highest degree of health at present attainable and to demonstrate that the raising of such stocks of plants, under conditions in which the risk of infection with virus and other

diseases was reduced to a minimum, was a perfectly practicable and commercial proposition. In the three years of the Scheme a total of over six million plants were sent out, consisting of 3,200,000 of the Royal Sovereign " clone " Malling 40, 14,600 Oberschlesien M.42, and 3,160,000 Huxleys. The latter comprised 665,000 plants of selected commercial stocks in the early years and, later, 2,495,000 of the tested clones M.43 and M.44. These plants and their progeny can now be seen in many parts of the country and the good performance of the clonal Sovereigns and Huxleys is well known. The Oberschlesiens, the last to be introduced to the Scheme, are as yet less extensively tested, but appear promising. The continued raising of these tested stocks under cultural conditions essentially similar to those of the Nuclear Stocks Scheme, but with the whole business enterprise in the hands of the growers themselves, is now catered for by the introduction of the Special Stocks Certificate described below.

The Special Stocks Certificate.—This Certificate will be given only to plants that reach the very highest standards. Only the tested pedigree stocks Royal Sovereign M.40, Huxley M.44 and Oberschlesien M.42 are accepted as parent plants. The runner beds must have isolation of at least one mile from other commercial beds, the plants must be raised by the " isolated block system ", and the most stringent disease and pest control measures and roguing are expected, as in the Nuclear Stocks Scheme.* Two inspections are made by the Ministry's Inspectors at the periods when virus diseases can best be observed, usually in June and September. At the final inspection the plants must be 100 per cent. true to type, and the number of unsatisfactory plants must not exceed 0·2 per cent. Application for this certificate had to be sent to the Ministry before 15th May, 1945 and the list of applications shows that, although the number of nurseries entered is rather more than in the last year of the Nuclear Stocks Scheme, the total acreage is rather less, especially in the Huxleys. The total Special Stock runner yields in the season 1945/6 may be expected to be of the order of 1,200,000 Royal Sovereign M.40, 650,000 Huxley M.44 and less than 150,000 Oberschlesien M.42, though of course actual yields depend greatly on weather conditions.

These " Special Stock " plants are comparable with " Stock Seed " potatoes. The best possible use for them would be for further propagation, and it is hoped that the bulk of them will be used for this purpose. Those growers who raise runners, either for their own use or for sale, would do well to make early application to the Special Stock growers, to avoid disappointment. A list of growers who have entered their stocks for the Special Stock Certificate may be obtained now from the Ministry of Agriculture, Berri Court Hotel, St. Annes, Lytham St. Annes, Lancs.

A small nucleus of Special Stock plants, for starting new nurseries is being maintained by East Malling Research Station, by arrangement with the Ministry. All available plants for the 1945 season are already allotted.

The Ordinary Certificate.—The Ministry's Ordinary Certificate is still available for plants raised under conditions which, although not nearly so stringent as those of the Special Stocks Certificate, do ensure that a reasonable commercial standard is maintained. The Ordinary Certificate is normally issued after an autumn inspection at which the plants must be found to be 99·5 per cent. true to type and free from substantial amounts of visible noxious diseases and pests. No stock is certified if it is less than 20 yards from another stock obviously affected with diseases and pests. The certificate depends solely on the appearance of the plants when inspected, however, and the history of the stock is not necessarily taken into account.

Thus a much wider range of plants can qualify for the Ordinary Certificate than for the Special Stock Certificate, and plants having the Ordinary Certificate are quite suitable for planting for cropping. Commercial varieties not yet available for the Special Stock Certificate can qualify for the Ordinary Certificate. It should also be noted that many little-grown varieties can also qualify, and the assessment of commercial importance is not a part of this Scheme.

Uncertified Plants.—Many growers consider that it is a great pity that uncertified plants may now be planted, and they have good reason for this opinion. An inspected stock that fails to obtain the Ordinary Certificate must have something wrong with it which makes it risky to plant. Even if a runner bed is intended entirely for one's own planting it is worth having it inspected, for the Research Stations keep increasing our knowledge of strawberry diseases and pests, and the Ministry's Inspectors and the County Horticultural Officers, from the nature of their work, keep abreast of these new discoveries and may be able to point out any new trouble in time to prevent its becoming serious.

The Conclusion.—The wisest policy, therefore, is to buy only Certified plants. Special Stock plants have the highest standard, and should be used where possible—especially for further propagation. The methods needed to qualify for this Certificate make such plants rather more expensive to raise, and they should justify a higher price to the grower than is asked for Ordinary Certificate plants. But good health in the strawberry plant is well worth paying for. For plants for fruiting

* A full description of the methods recommended appeared in the *E. Malling Res. Sta. Annual Report* for 1943 and a reprint of this article (E.216) can be obtained, price 10d., postage extra, from the Secretary.

quantity, the Ordinary Certificate should be the minimum qualification. If the Ordinary Certificate plants are " once grown " Special Stock plants, then they have the added guarantee of being a tested one—a great advantage.

It is now known and proved that good healthy runners can be raised. Whether their raising and use will be continued and expanded, thus gradually improving the whole standard of strawberry production, now depends on growers themselves.

The end of the Nuclear Stocks Scheme does not imply a lessening of interest by research workers in strawberry problems. Far from it ; for further work on the viruses, regular re-testing of the old stones, and collecting and testing of new stocks and other varieties must continue if the standard is to be maintained and improved. Also, though the planting of good material is half the battle, there is the other half, cultural measures and disease and pest control in the fruiting bed. These demand close attention, both on the part of the grower and the research worker.

Summary.—With the termination of the Ministry of Agriculture's Strawberry Nuclear Stock Scheme, the measures taken to ensure the continued supply of healthy plants by means of the Special Stock and Ordinary Certificates are described. A strong recommendation is made that growers should plant none but certified plants.

THE BRADBOURNE WALLED GARDENS

By T. N. HOBLYN*

In last year's Report we described the small fruit gardens, designed to show the amateur how to make the most of restricted space. During the winter 1944-5 we started planting up the larger walled garden. This garden, a plan of which, as it will eventually appear, is given in Fig. 1, is designed to give the lover of fruit trees and fruit an opportunity of seeing all the more important methods of growing and training fruit trees intensively. At the same time he will find therein, and we hope in due season sample, a selection of varieties famous for their flavour, for their looks, or for both.

The main walls in the garden will be devoted to peaches. Two varieties Peregrine and Sea Eagle will be grown and, to show what can be done with small walls as well as large, they will be worked on both dwarfing and vigorous rootstocks. The very high wall of the old ballroom, which faces east, will house a collection of pears grown as upright cordons.

The body of the garden has now been planted half with apples and half with pears. The bulk of these are grown as dwarf pyramids and cordons, worked on dwarfing and semi-dwarfing rootstocks, M.IX and M.VII for the apples, and quinces A and C for the pears ; Williams' bon Chrétien which will not grow direct on quince, is doubleworked. Bordering the walks, however, the tree fancier will find apples and pears trained as " espaliers ", " arcures ", and " double U " trees, while at intervals graceful arches will cross the path. Only a small part of the garden will be devoted to experiments and here we shall try various methods of pruning dwarf pyramid trees.

Much thought has gone to the choosing of the varieties, only a few of which will be found in commerce. Thus Cox's Orange Pippin which Edward Bunyard in his *Anatomy of Dessert* called " the queen of apples " could not be omitted ; nor could we leave out Conference pear, for, though the connoisseur may pass it by in years of plenty, he may yet be glad to welcome it to his table when its better flavoured brethren are taking a year off. With the rest epicures will find little fault. Among the apples they will find several that they know well, James Grieve, King of the Pippins, Egremont Russet and Ribston Pippin :

> In russet clad, and o'er his noble head
> A halo spread,
> He reigns upon a cordon lifted high,
> The very wasps salute as they pass by.
> (*Eden Philpotts*).

while those who look forward to the days when a glass of vintage port is no longer a wartime dream, will rejoice to find Orleans Reinette, " rich and mellow ", not only taking its place in the garden as the king of its season, but also ranged among those in the south-eastern corner from which we can expect some fruit even in frosty seasons. Those who are so unfortunate as to own a garden liable to late spring frosts will particularly appreciate this corner.

* From information supplied by various members of the Pomology Section who have helped in the design of the gardens.

Along the walks there are many that appeal to the eye as well as the palate, Lady Sudeley with her "flaming scarlet fruits", Adams Pearmain "dappled with grey spots on its red-gold sides", and that "most comfortable-looking fruit in sober russet" Claygate Pearmain. As well as these older and better known aristocrats of the garden, we have included some of the younger generation Laxton's Fortune, Sunset and, if we can keep it healthy, Lord Lambourne, the first two of which are descendants of Cox's Orange, while from abroad we have adopted Wagener and Granny Smith.

For the lover of good pears the season opens in July with Doyenne d'Été and from then until February there is a series of fine varieties, Williams' bon Chrétien (the Bartlett of North America), Laxton's Superb, Beurré Superfin, Fondante d'Automne, bringing us to the climax of the year when Doyenné du Comice, that most delectable of all pears, graces the table. Glou Morceau, Winter Nelis follow, while others less well-known have been found worthy of a place in the garden, each in season having its own particular merit. Lastly, at the cross-paths, Durondeau with its lovely golden brown fruits each with its slight flush of scarlet, has found a place of honour.

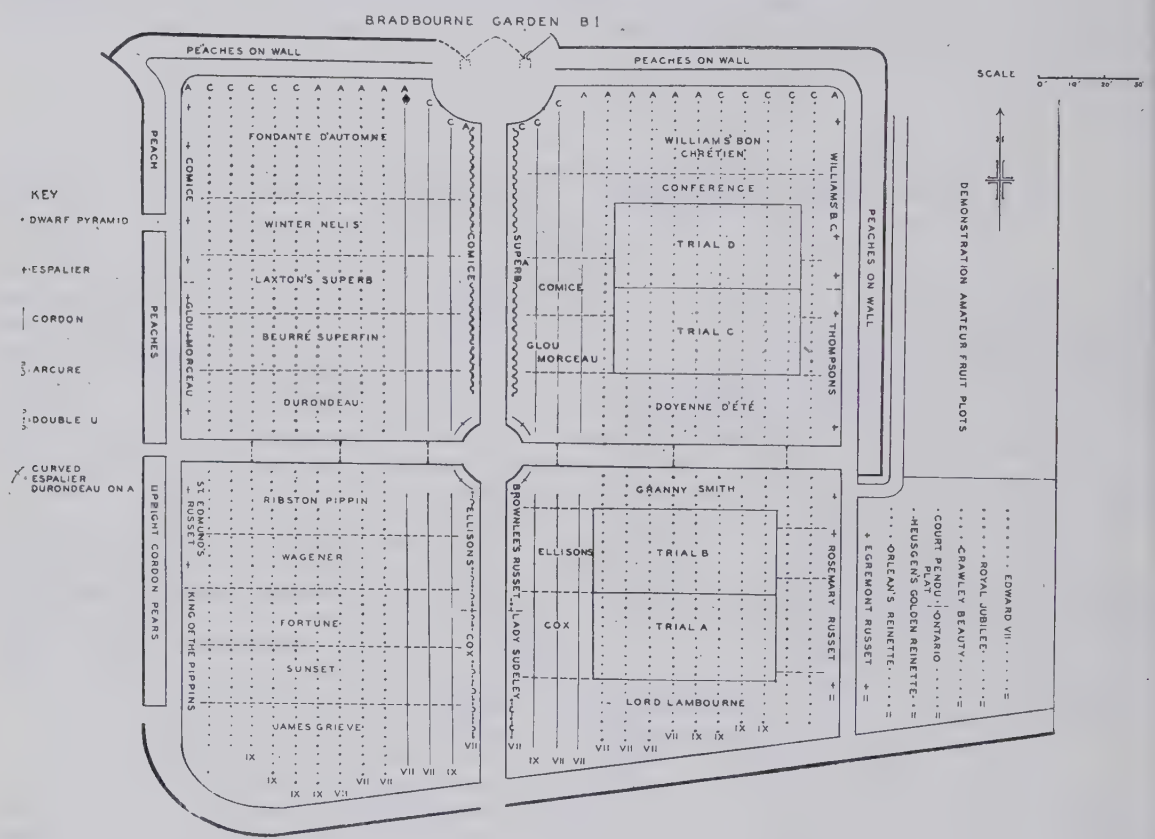


Fig. 1.

A word remains to be said about the small walled garden adjoining, the trees for which are now in the nursery. On the walls there will again be peaches, but until these require all the space, our collection of apricots "shining in a sweet brightness of golden velvet" will share the walls as temporary fillers. Why is the apricot no longer found on our garden walls, except in special districts and even there less frequently than of old? Perhaps we shall find out! In the centre of this garden we are going to undertake a trial of six peach varieties grown as bushes in the open, Barrington, Bellegarde, Peregrine, Rochester, Hales Early and Libra. These are not yet ready for planting, but when they are, all those of us who long to grow peaches, but have no suitable wall space, will watch with particular interest this part of the Bradbourne gardens.

A full list of all the varieties in the garden is given below arranged in order of their approximate season.

Summary.—A description and complete list of the varieties of apples, pears, peaches and apricots to be planted in the walled gardens at Bradbourne.

Month.	Apples.	Pears.	Apricots.	Peaches.
July		Doyenné d'Été.	Early Cape. New Large Early. Early Frogmore. Large Early. Early Moorpark. Bulida. Royal (South Africa)	
August	Lady Sudeley.	Laxton's Superb.	*Old Cape. *Veitch's Red. Moorpark. *Grosse Pêche. Hemskerk. *Croughton. Shipley. Royal. St. Ambroise. Breda. *Bradbourne.	Hales Early. Peregrine. Rochester.
September ..	James Grieve. St. Everard. Fortune. Ellison's Orange.	Williams' bon Chrétien, Légipont. Packhams Triumph.		Barrington. Bellegarde. Libra. Sea Eagle.
October	Egremont Russet. St. Edmund's Russet. Lord Lambourne.	Beurré Superfin. Fondante d'Automne. Emile d'Heyst. Conference. Thompsons. Durondeau.		
November ..	King of the Pippins. Sunset.	Doyenné du Comice.		
December ..	Cox's Orange Pippin. Ribston Pippin. Rosemary Russet.	Comptesse de Paris. Winter Nelis. Glou Morceau.		
January	Adams' Pearmain. Brownlees Russet. Claygate Pearmain.			
February ..				
March	Wagener.			
April	Granny Smith.			
	Late Blossoming and Frost Resistant Varieties.			
October	Royal Jubilee.			
November ..	—			
December ..	—			
January ..	Crawley Beauty. Orleans Reinette.			
February ..	Edward VII.			
March	Ontario. Court Pendu Plat. Heusgens Golden Reinette.			

* Exact season not yet known.

SPRAYS TO PREVENT PRE-HARVEST DROP OF FRUIT

By M. C. VYVYAN

In 1880 Charles Darwin published his observations on how seedlings of grass, illuminated from one side, bend towards the light. He showed that the light was "perceived" by the tip of the seedling, and not by the lower part where the bending took place, and that there must therefore be a "messenger" carrying the stimulus from tip to the region of action.

In 1910 a Dane, Boysen-Jensen, showed that this messenger would pass through a layer of gelatine, and in 1926, a Dutchman, Went, stood tips of seedlings on gelatine and found he could collect the messenger in it, thus proving it to be a substance. Chemists got busy and found out, more or less, the nature of the substance, and discovered or made others, which acted in much the same way. These substances, known as hormones, were soon found to be capable of stimulating the production of roots on stems, and work on their use for improving rooting of cuttings was carried out widely.

Cuttings are usually planted with a few leaves on, but these generally fall off rather early. It was found that in cuttings that had been treated with these growth substances, the leaves tended to remain on much longer; and other more direct experiments showed likewise that these substances retarded the shedding of leaves.

As the mechanism involved in the shedding of fruit is rather similar to that in the shedding of leaves, certain Americans, Gardner, Batjer and Marth, examined the possibility that these substances might prevent fruit drop. Their experiments (1939) were very successful and their main results were as follows:

(*a*) The most effective substances were alpha-naphthalene acetamide, alpha-naphthalene acetic acid or one of its salts.

(*b*) Only very low concentrations were required, e.g. 2½ or 5 parts per million, though 10 parts per million might be advisable for general use.

(*c*) Substance must wet the actual fruit stem to be effective.

(*d*) Sprays were more effective in warm weather than in cool.

(*e*) The addition of spreaders and oil seemed to increase the effect.

(*f*) The effect took a few days to become apparent, rose to a maximum, then wore off rather quickly. The duration depended partly on the variety.

(*g*) Large varietal differences were found. In general, long-stemmed varieties responded best; probably because their stems are more easily wetted and the spray retained in cavities. Early varieties usually responded better than late ones.

Experiments at East Malling were started in 1940. The substance alpha-naphthalene acetic acid was used at concentrations of from 2½ to 10 parts per million—the strengths recommended by the U.S.A. workers.

Beauty of Bath.—This variety tends to drop very heavily before it is in its best condition for picking. It has usually to be picked over several times, if a reasonable proportion of the crop is to be secured; or the fruit may be allowed to drop on to straw. It will be realized, however, that increase in size and quality continues so long as the fruit remains on the tree,—though ultimately the fruit might become too ripe.

On the strength of the results with Beauty of Bath, it seemed safe to recommend the use of a spray, at a concentration of about 10 p.p.m., for this variety. It should be put on about 10 days or a fortnight before the date when the fruit would normally be picked. Picking can be postponed a few days, but care must be taken to prevent the fruit from becoming over-ripe through being left on the trees too long.

Worcester.—Good results were also obtained with Worcester, the saving in crop in 1940, when only a light drop occurred, being equivalent to about 30 or 40 bushels per acre, while in 1943, when picking was delayed about four days after the normal time, and a heavy drop resulted, the saving worked out at about 180 bushels on a crop of about 550 bushels per acre.

Miller's Seedling gave almost as good a result, and the fruit from the sprayed trees, though picked at the same time as that from unsprayed trees, had a higher colour.

The spray for these last two varieties should be applied about three weeks before the normal picking date, or earlier if an appreciable drop begins.

Bramley.—The results with Bramley being inconclusive so far, we cannot recommend the use of this spray for this variety.

Conference Pear.—A marked reduction in fruit drop was obtained with 4 parts per million applied 11 days before the normal picking date, when picking was postponed for a fortnight. The total drop at time of picking was over 20 per cent. from the unsprayed and only about 5 per cent. from the sprayed.

Cox's Orange Pippin.—The experiments with this variety were designed to see if the hormone ould prevent the fruit drop that frequently occurs when summer petroleum oil is used. In the ears when the spray was tried the oil caused no increase in drop, but the growth substance spray ightly reduced the normal drop. On the basis of these results, we cannot say that the sprays are oing to be useful for Cox ; further work will be required. If used on a variety such as this, timing an open question, for the period in which dropping occurs is longer than that during which the pray is likely to be active. Possibly an early application would be useful, as the after-ffect of the spray seems to be fairly persistent ; moreover this variety sometimes shows a fairly eavy drop at an early stage. If, however, it is required to delay picking for a week or so after the ormal date, spraying should be delayed to a date not more than four weeks before the date it is roposed to pick, so as to give the substance a chance to be still active when dropping is likely to ncrease. Care must be taken to prevent over maturity, especially if storage is intended.

Practical Recommendations.—1. *Varieties worth spraying.*—The apple varieties, Beauty of ath, Miller's Seedling and Worcester, and the pear Conference are certainly worth spraying. We o not know enough about the response of other varieties yet, to give a general recommendation.

2. *Occasions when it is worth spraying.*—When heavy drop is expected before the fruit can be icked, or when the fruit would have to be picked too soon so as to avoid such a drop. Sprays are specially useful when the period of picking is likely to be long, owing to a large acreage or shortage f labour ; here it may be sufficient to spray only those trees that will be picked last.

3. *Materials to use.*—Alpha-naphthalene acetamide, alpha-naphthalene acetic acid, and the alts of the acid, seem equally effective, but most growers will probably find one of the commercial preparations more convenient.

4. *Strength.*—The pure chemicals should be used at 10 parts per million (0·001 per cent.), and he commercial preparations according to directions. Weaker sprays are often effective, but the saving n cost of material is too small to justify the risk of getting less effect.

5. *Quantities per tree.*—About a gallon, or a little more, of spray, should be applied for every ushel of fruit on the tree. Spray from inside as well as from the outside of the tree, and from above ather than from below, so as to hit the fruit stalks. Make a thorough job of the top part of the tree.

6. *Time to apply.*—Only tentative recommendations can be made. Ten days before normal icking date seems about right for Beauty of Bath, three weeks for the other varieties. If appreciable rop begins a little earlier, apply the spray at once. Choose a hot day if possible, but if cool weather annot be avoided, increase the strength of the spray. Do not spray if it is likely to rain soon ; rain ight hours after spraying does not seem to reduce the effect.

7. *Time to pick.*—The sprays may allow for the picking to be postponed a few days, which some-times improves colour and quality, but care must be taken to pick before the fruit becomes over-ripe.

Summary.—Experiments in the use of growth substances sprayed on the trees to prevent fruit drop are described, and recommendations made for the use of such sprays and the varieties on which they have proved successful in commercial practice.

THE CURE OF DEFICIENCIES OF IRON OR MANGANESE

By S. G. THOMPSON

THE attention of growers was drawn* to the three deficiencies, viz. : iron, manganese and magnesium, commonly met with in fruit in England.

The object of the present bulletin is to discuss the means growers can adopt for curing iron or manganese deficiency when either has been diagnosed in apples, pears, plums, cherries or peaches. It was pointed out in the previous Bulletin that iron or manganese deficiencies are usually of the " induced " type, i.e. the element is present in adequate amount in the soil but is unavailable to the plant. Consequently applications to the soil are of little or no value and the choice lies between using injection or sprays ; both are effective and which is better used depends on the circumstances of each case and the considerations detailed below.

Solid Injection.†—Iron or manganese sulphate is put into the tree in the form of standard 1 gramme tablets. The number of holes and of tablets per hole required to effect a cure and to reach all parts of a tree of any size can be read off on the Dosage Table, and no calculation

* See Annual Report for 1943, pp. 103-4.

† " Solid " injection only is discussed, as " liquid " injection, though effective, needs greater care in dosage and is not so easy or quick to operate.

of dose is necessary. The whole operation described below can be done by a team of two after some practice, in an average time of one minute per hole ; thus a standard or half-standard tree with a trunk of 16 inch girth requires 5 holes and takes 5 minutes to complete, or a large old tree of 60 inch girth, requiring 20 holes, 20 minutes : bushes with short " legs " involve much stooping and will take rather longer than standards. Thus it is easy to make a rough calculation of the time needed to inject a number of trees of fairly uniform size by measuring the girth of a few trees to find the average trunk measurement and finding the number of holes from the Table.

The apparatus required is*:—

Braces 1. (2 advised for quick work to avoid constant changing of bits.)

Bits 1, $\frac{5}{8}$ inch, 1, $\frac{1}{2}$ inch. IRWIN make recommended. (Bits must be kept sharp, and a spare pair is useful if many trees are to be injected.)

Injection gun.† (See Fig. 1) 1 or 2.

Dosage Table. Preferably copied on to a card, which is then dipped in liquid paraffin wax.

Supply of iron and/or manganese sulphate 1 gramme tablets.‡

Supply of corks cut to size.

Tape marked in inches.

Technique of Injection.—The " drill " for injecting a number of trees given below is based on a team of two persons and has been found to result in smooth working. One person can do the whole operation, but will take much longer per tree owing to continued changing of tools.

Worker A. has brace with $\frac{5}{8}$ inch bit and tape measure.

He puts tape round tree at a convenient height, secures it to trunk with a push pin, and notes girth in inches ; reference to the Dosage Table shows the number of holes to bore and their distance apart, and the number of tablets required per hole. (Alternatively, a special tape may be prepared from which the number of holes and tablets can be read direct.)

A. goes round the tree drilling with the $\frac{5}{8}$ inch bit just deep enough to cut out the bark cleanly and expose the wood, making a zigzag pattern above and below the tape which acts as a guide, except for trees with slim trunks when the holes are drilled in a spiral to avoid weakening the trunk unduly at one level.

Worker B. follows *A.* round the tree with a brace with the $\frac{1}{2}$ inch bit, being careful to use the same centre as *A.* and drills horizontally towards the centre of the trunk a hole deep enough to receive the number of tablets required and the cork.

A. finishes drilling before *B.*, and then scrapes out any chips from the holes with a knife or hacksaw blade as *B.* finishes them. When all holes are drilled and scraped clean, *A.* fills the tube of the injection gun with the necessary tablets and cork at the rear end and hands it to *B.*, who rests the end of the tube in the recess made by the $\frac{5}{8}$ inch bit and pushes gently, when the tablets and cork should go in easily ; unnecessary force tends to break the tablets and cause a jam. While *B.* is injecting, *A.* is filling a second injection gun and so on.

If the hole has been bored straight and clean, the tablets go in easily without breaking, no chemical touches the bark and the cork closes the hole flush with the wood, thus forming a surface over which the bark will grow as the hole heals.

If the hole is not quite straight the tablets may break and a little of the chemical may work past the cork ; if so, it is scraped off with a knife blade.§

Cost of Injection.—If many trees are to be injected the first cost of the apparatus will be negligible ; as braces are available on every farm the only necessities are 2 bits at 4s. 6d. each and an injection gun. With iron and manganese tablets costing 14s. 6d. per 1,000 and corks at 1s. 8d. per gross the cost per tree will range from approximately $\frac{1}{4}$d. for a young tree of 7 inch girth to approximately 1s. 4d. for a large old tree of 60 inch girth, plus labour cost of 2 minutes and 20 minutes respectively.

Results of Injection.—If trees are injected in winter or early spring complete return of healthy green colour in foliage, and an increase of extension growth and bud formation can be expected in the following summer and autumn, with an effect on crop the next season.

The beneficial effect lasts at least five years, and will then gradually diminish, when the question will arise whether to inject the trees again or to keep them healthy by sprays. While injection in winter or early spring is advised, trees have been injected in summer and autumn without injury, but the effect is usually not seen until the following season.

* The apparatus and technique differ slightly from those described by Mr. C. R. Thompson. *The Market Grower*, vol. 22, 42-3, 1944.

† Messrs. Griffin and Son, High Street, West Malling make an injection gun according to our specification.

‡ Messrs. Boots, Cash Chemists supply these tablets.

§ Further information on the technique of Injection will be found in Technical Communication No. 16, obtainable from I.A.B., Central Sales Branch, Penglais, Aberystwyth, 1s. 6d. post free.

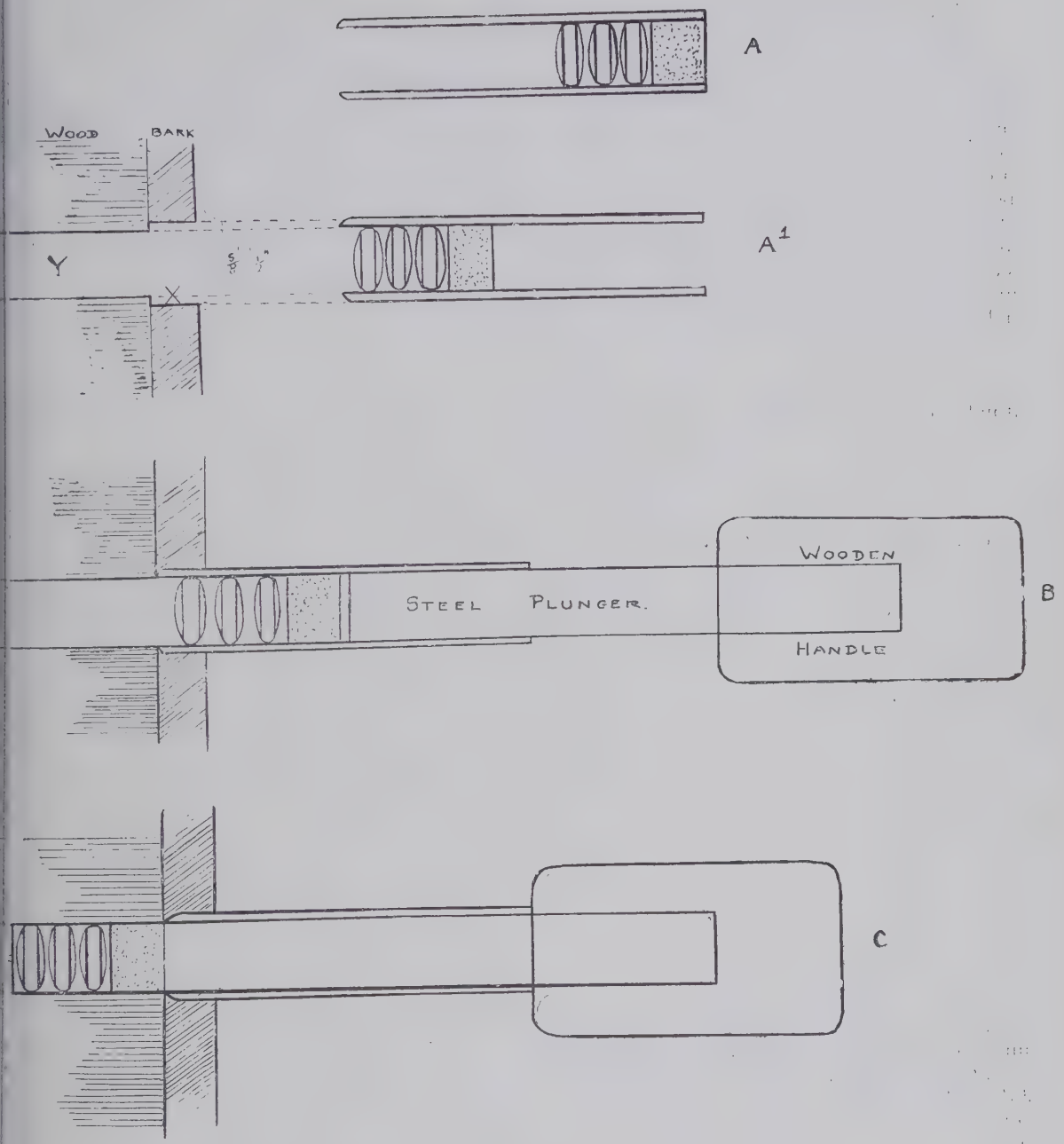


FIG. 1.

A. Metal tube with cork put in at rear end and tablets inserted from front end.

A1 Note recess X made by $\frac{5}{8}$ in. bit to receive end of tube and hole Y of sufficient depth to receive tablets and cork.

B. Position before insertion of tablets and cork: note that tablets are not in contact with bark, and that tablets and cork are pushed to front end of tube: a gentle push then places them in position without risk of tablets breaking and jamming in hole.

C. Tablets and cork pushed home.

The above diagrams are adapted from Technical Communication No. 16, by W. A. Roach and W. O. Roberts.

SPECIFICATION OF INJECTION GUN.

Tube: Steel, $\frac{1}{2}$ inch internal and $\frac{5}{8}$ inch external diameter, externally bevelled at one end, length 3 inches.

Plunger: of silver steel made to an easy fit in tube, fitted into wooden handle so that the face of the plunger is flush with bevelled end of tube when pushed home.

Advantages of injection.—These are :

(1) The very complete and long lasting cure obtained.

(2) The work can be done at any convenient time during winter and spring and in any weather except heavy rain, and not necessarily by highly paid labour.

Disadvantages of Injection.—Some growers dislike the idea of making holes in the trunk for fear of disease. If bits are kept sharp and clean-cut holes are made, and if care is taken that none of the chemical touches the bark, healing is rapid and the risk is no greater than for pruning cuts. Disinfecting the bit before commencing on another tree, and closing the hole with grafting wax have been advocated and are useful precautions, but in our experience do not seem to be necessary. With cherries, and, to a less extent, plums, there is a risk of gumming from the holes, but usually no appreciable gumming occurs and, even when it does, there is no evidence as yet that trees have been harmed. Very young trees with slim trunks (say 6 inch girth and under) should not be injected as the trunk may be weakened, but no instance of a trunk of a fair sized tree being unduly weakened, when the holes are staggered, has yet been met with.

Dosage Table.

For Solid Injections of 1 gramme tablets of Iron (ferrous) sulphate, or Manganese sulphate; applicable to apples, plums, pears and cherries.

Tree circumference in inches.	Holes. No. per tree.	Holes. Approximate depth in inches.	No. of tablets per hole.	Tablets per tree.
7	1	1	1	1
9	2	1½	1	2
12	4	1½	1	4
16	5	1½	1	5
19	6	2	Alternate 1 and 2	9
22	7	2	,, ,,	11
25	8	2	2	16
28	9	2½	2	18
31	10	2½	Alternate 2 and 3	25
35	11	2½	,, ,,	28
38	12	2½	3	36
41	13	3	3	39
44	14	3	Alternate 3 and 4	49
47	15	3	,, ,,	53
50	16	3	4	64
54	18	3	4	72
57	19	3	Alternate 4 and 5	86
60	20	3	,, ,,	90
66	22	3	5	110
69	23	3	5	115

Sprays.—Either summer or winter (dormant) sprays may be used : the latter, on our present limited experience, seem more effective and safer than summer sprays.

Summer Sprays.—Owing to the possibility of damage to foliage (most likely on trees in a bad state of health) it is advisable to spray a few branches with the strength of spray intended, a little time before the main application ; then if damage is noted the strength is reduced. Slight damage may be neglected as trees soon recover. Manganese sprays rarely cause any damage but iron sprays should be used with caution ; the addition of half the weight of the iron or manganese salt of hydrated lime tends to prevent damage.

The formulae advised for summer sprays (reduce to half strength if small trials show damage) are :

Iron.—5 lbs. ferrous sulphate + 2½ lbs. hydrated lime + spreader (0·1 per cent. liquid Agral, or equivalent) per 100 gallons.

Manganese.—10 lbs. manganese sulphate + 5 lbs. hydrated lime + spreader per 100 gallons.

Cost of chemical at 55s. cwt. for manganese sulphate would be approximately 5s. per 100 gallons.

With summer sprays, the new foliage that develops some time after the spraying may show deficiency symptoms and for complete control a second or even third spray is sometimes needed. The best results follow from spraying late in the day or in dull weather, when the leaves dry slowly and more solution is absorbed. Rain shortly after spraying will, of course, reduce the effect.

Where possible it is naturally desirable to add these chemicals to an existing spray, thus saving time and labour, and with apples the most suitable one is the post-blossom lime-sulphur. This is not advised, however, in the case of iron as the result is a black ink-like liquid very unpleasant to handle. 2½ lbs. manganese sulphate may safely be added to 100 gallons lime-sulphur, but care should be taken to wash out the apparatus and pipes thoroughly after spraying as the mixture is liable to produce deposits; careful washing out is also necessary when manganese sulphate is used alone. There is no objection to adding iron or manganese sulphate to a nicotine spray. However, if there is a deficiency serious enough to warrant treatment, a separate spray may be considered worth while.

Winter Sprays.—Experience with winter sprays under English conditions is, as yet, small but has so far confirmed South African reports that the results are more marked and more lasting than summer sprays, and the advantage of application in a comparatively slack season of the year is obvious, but until further experience has been gained a general recommendation of winter sprays would not be justified.

If a winter spray is tried it should precede the routine winter wash and, as the effect depends on the amount of salt absorbed through the bark, a day should be chosen when immediate rain is not likely. Damage may result if it is applied on very cold and windy days, but otherwise winter sprays seem to be safer than summer sprays.

The formulae suggested for winter sprays are:

Iron.	Severe deficiencies.	10 lbs.	ferrous sulphate per 100 gallons.
	Slight „	5 lbs.	„ „ „ „
Manganese.	Severe deficiencies.	50 lbs.	manganese sulphate per 100 gallons.
	Slight „	25 lbs.	„ „ „ „

In one case of severe deficiency, manganese sulphate used at the above strengths on *cherries* as late as bud-break caused no damage and gave excellent control of the deficiency.

Advantages of sprays.—Small trials on branches, with the rest of a tree as control, can easily be made with a syringe or knapsack, and the effect noted; the strength of sprays can then be varied to suit the case. Spraying apparatus is available on every farm, and there is no new technique to be learned.

Disadvantages of sprays.—They are rather variable in effect and cannot be relied on to remain effective longer than one season, so that in serious cases a spray must become part of the annual routine. Particularly with iron, there is some risk of damage.

With the above considerations in mind, growers who are faced with a deficiency problem can make a long term plan to eliminate it. When serious deficiency (shown by symptoms such as marked chlorosis, die-back, lack of extension growth and poor cropping) is present, the advantages of injection outweigh the disadvantages and we recommend its adoption; for very young trees, and when the deficiency is not very serious, sprays are more appropriate. When sprays are adopted on any large scale, growers are urged to make their own experiments by spraying single branches with a hand sprayer to find out the best strength and time of spraying; and to leave controls unsprayed both to give a measure of the effect, and to find out whether a spray every second or third year is enough to keep their trees in condition. As mentioned above, the effects of spraying are variable and the spray formulae given are intended as general guides which can be varied according to experience.

Small experiments, either by sprays or injection (which can be done on single branches), are also worth while if there are trees, near a known deficient area, that do not show obvious symptoms of deficiency, since such trees may well be suffering from the deficiency sufficiently to affect their growth and cropping. It may be mentioned that it has proved commercially profitable to spray certain agricultural crops growing in a known deficient area, even though they showed no symptoms of deficiency.

It may well be more profitable to give treatment before symptoms appear than after trees have been checked in their normal development.

The incidence of a deficiency is seldom the same over any large area: there are usually patches where trees are considerably worse than elsewhere. It is suggested that when a large area needs treatment a plan should be drawn up: that the worst parts be treated as blocks wherein all trees are to be injected, that better parts should be given routine sprays, and doubtful areas which show very slight or no symptoms should be tested by small trials. It should be possible after a few years experience to clear up the trouble for the time being and to decide on a programme of occasional routine sprays sufficient to avoid any future recurrence and ensure that no loss of crop will be caused by these deficiencies.

Summary.—Curative measures for iron and manganese deficiency are discussed. Injection is recommended when deficiencies are serious, otherwise either summer or possibly winter sprays.

THE CONTROL OF BROWN ROT OF APPLES IN COMMERCIAL ORCHARDS

By H. WORMALD and M. H. MOORE

THE Brown Rot diseases of fruit trees in Britain are caused by two fungi, *Sclerotinia fructigena* (*Monilia fructigena*) and *Sclerotinia laxa* (*Monilia cinerea*). Both fungi cause Brown Rot of the fruit, and *Sclerotinia laxa* produces Blossom Wilt also. They attack not only fruit trees but also various ornamental shrubs, and these may therefore be sources of infection for fruit trees. Moreover, any one kind of top fruit may serve as a source from which other kinds can become infected. For instance, both fungi attack plums ; as plum trees are sometimes interplanted with apples, not only the apples but also the plums must be kept as free as possible from Brown Rot, for, if not, the apples will become infected from the plums. Again *Monilia fructigena* has been found on cobnuts affected with a Nut Drop disease ; this suggests that cobnuts may become infected from, and may serve to infect, fruit trees such as apples, pears, plums, and cherries.

Recent Surveys on Commercial Farms.—During the last two years (1943 and 1944) Brown Rot of apple fruits has been severe, and observations have been made to determine the chief factors involved in these recent outbreaks. This disease on apples, almost invariably caused by *Sclerotinia* (*Monilia*) *fructigena*, can be recognized by the yellowish, cushion-like, powdery fructifications of the fungus, often in concentric rings round the point where infection entered.

The sources of infection in any one year are : (1) Mummied fruits overwintering on the trees. (2) Infected fruits of the previous season, dropped and overwintered on the ground. (3) Branches and fruiting spurs infected during the previous season and allowed to remain on the trees. (See Fig. 1.)

Cankers and mummied fruits bearing sporing fructifications of the fungus have been found as early as the middle of May. The disease can thus spread through the plantations from May until picking time, and any fruit taken into store with the slightest injury will almost certainly begin to develop Brown Rot (often turning to Black Apple rot) during storage.

Visits were paid in 1944 to a fruitgrowing area where Brown Rot of apples had caused much wastage in previous years. About the middle of July there were already many rotten or rotting fruitlets of the current year, most of them bearing fructifications (and so scattering innumerable spores) of the Fruit Brown Rot fungus. Many fruits had been pecked by birds and the injuries so made became ports of entry for Brown Rot, and aggravated the disease. The two varieties most severely affected at this time were James Grieve and Laxton's Superb. In a search for sources of infection no mummied fruits (a common source of infection) were found on the trees in the plantations visited, but the fungus was found on some of the previous year's fruit that had been left under the trees. The most serious sources of infection in these plantations were dead spurs and cankered branches that had become infected during the previous season ; they were mostly on the varieties James Grieve and Laxton's Superb, and spore cushions were bursting through the bark and scattering spores. These two varieties, used as pollinators for Cox's Orange Pippin, are thus very susceptible not only to fruit rot but also to infection (through the fruit) of the spurs and branches. These are sources of infection that may not only very easily be overlooked, but are frequently confused with Apple Canker, which is caused by an entirely different fungus.

A possible approach to the problem is the selection of varieties less susceptible to Brown Rot for use as pollinator varieties in plantations of Cox's Orange Pippin. Infection through the uninjured skin can be induced under laboratory conditions, but it appears to be rare in the orchard, and any Brown Rot infection can almost always be traced to wounds caused by hail, Scab, birds, biting insects, such as wasps, and the larvae of Apple Sawfly, and in particular of Codling Moth. It is to be noted, however, that when infection starts on one apple of a cluster, the disease can extend by contact to all the fruit in that cluster.

Any measures taken to reduce such injuries to a minimum will thus lessen the chances of an early outbreak of Brown Rot. All efforts should be directed against the early attacks, for when the disease starts, even on a small scale, it will spread rapidly during the summer if the weather conditions are favourable for the fungus.

Experiments at East Malling have shown that, where there is good control of Apple Scab, there is less Brown Rot infection of the fruit. Thorough control of Scab, therefore, not only for itself, but also for reducing chances of infection from Brown Rot, is essential for increasing the quantity and quality of the fruit.

Control Measures Recommended.—Past experience has shown that there is little prospect of *directly* controlling Brown Rot by spraying with lime-sulphur. Whether spraying (or dusting) with some of the newer fungicides offers any more hope is at present an open question that can only be decided by field trials. Meanwhile, our observations and experiments indicate that if attention is paid to the following recommendations, an appreciable improvement will be effected:

FIG. 1.
Branch Canker on Miller's Seedling, 1945. Note mummied fruit of 1944, from which infection of branch arose.

(1) All overwintering sources of infection should be removed and destroyed by early spring. This will involve (*a*) removing and destroying all mummied fruits by burning or deep burying, (*b*) cutting off and burning infected spurs and branches, (*c*) throwing all rotten fruits into the alley-ways and not under the trees, so that they can be ploughed or disced in and thus rendered harmless.

(2) Routine measures for the control of Apple Scab, Sawfly, and Codling Moth should be thoroughly carried out.

(3) Wasps' nests in the neighbourhood of fruit trees should be sought out and destroyed.

(4) Where birds are found to be a nuisance, by pecking the fruit, some method of bird-scaring should be adopted.

(5) Similar measures, where appropriate, for the control of Brown Rot should be applied to plum trees interplanted with apples or growing near them, particularly with regard to the removal of mummied fruits after a bumper crop.

(6) Any fruits bruised or injured in any way, or picked without their stalks, should not be stored; they probably carry spores from the orchard on their skins and infection will arise through the wounds.

(7) Co-operation is necessary among growers over as wide an area as possible, for the Brown Rot spores are very light and are carried in the air for considerable distances. A neglected orchard is a menace to those around.

Summary.—The causes underlying severe outbreaks of Apple Brown Rot are described, and control measures are outlined.

THE HOP RED SPIDER (*TETRANYCHUS TELARIUS* L.)

By A. M. MASSEE

The Hop Red Spider has been very prevalent in various districts of Kent and Worcestershire during the past two seasons, and has materially reduced the crop in many gardens or hop yards. In most seasons the variety Fuggle is more subject to attack than other varieties, but in 1944 bad outbreaks occurred in the Golding varieties as well, probably partly due to the drought conditions prevailing up to the middle of August.

Control Measures.—Recently the measures suggested for the control of red spider have been modified considerably, and the older practice of spraying the hops in August with liver of sulphur has been completely superseded by the application of a one per cent. lime-sulphur spray, with a suitable wetter, at the end of May or early June. In practice the spray should be applied when the lower leaves of the bines have been stripped, but before they reach the breast (or tying-in) wire. If the Hop-Damson Aphid or Hop Fly is also present, nicotine may be added to the lime-sulphur spray. One application may prove sufficient, but in seasons when the red spiders come out of hibernation over a long period, a second application should be made about a week to ten days later. The object of this early lime-sulphur spray is to destroy the adult female mites before they begin to lay eggs on the leaves, and start to spin a canopy of webbing on the under-surfaces of the foliage. All hop gardens that have suffered from a severe attack of red spider during the past two seasons should receive this spray as a routine measure.

If the red spider attack is not detected until the latter part of July or in August, it is still safe to apply a one per cent. lime-sulphur spray. It must be emphasized, however, that the presence of red spider eggs, which can not be killed by lime-sulphur, and the protective canopy of fine silk considerably reduce the effectiveness of the spray. Also if the bines have been materially checked or stunted by the infestation or by a severe attack of aphis, then slight leaf injury may result on some varieties.

The spray can be applied by means of a power sprayer or by a " hop washer " machine. A medium spray should be used, care being taken to wet the under-surface of the leaves very thoroughly.

Experiments carried out at East Malling and experience gained in the field show that the above spray will not scorch the leaves or check the growth, provided the spray is not applied during the hottest part of a sunny day in a " housed in " garden. Care must, however, be taken to insure that it does not coincide with the routine copper spray or dust, used against Downy Mildew. A period of ten days should elapse between the application of the two sprays.

Subsidiary Control Measures.—When a garden is so badly infested that the foliage turns brown and the hops are unsuitable for picking, an effort should be made to burn the bines before the red spiders migrate from the leaves and seek their winter quarters during the latter part of September. When cutting the bines before burning, two or three feet of bine should be left attached to the hill to reduce the amount of " bleeding " which results from early cutting. Where the red spider population has been abnormal, it is also useful to broadcast 5 cwt. of crude commercial naphthalene to the acre directly after picking. This treatment is also partially effective against the Hop Strig Maggot, another important hop pest.

The spraying of the poles with a tar wash, petroleum or lime-sulphur spray is not recommended, for while it is true that large numbers of red spiders hibernate in the cracks of poles, in beetle holes and

crevices, it is not possible to direct the spray effectively into such situations. Dipping the poles in an insecticide to destroy the red spiders is also of very little use, since airlocks are formed in the cracks and crevices of the poles and the animals are not reached by the wash.

Briefly, *to control Hop Red Spider* :—

Spray in May or early June, when the lower leaves of the bines have been stripped but before they reach the breast (or tying-in) wire. If required, spray again ten days later.

Formula :	Lime-sulphur	1 part.
	Water	99 parts.
	Wetter (according to makers' directions)	about 6 ozs.
	Nicotine (can be added if Hop Fly is present)	5 ozs.

Summary.—Measures are described for the control of Hop Red Spider ; the most important of these is a one per cent. lime-sulphur spray in May or early June.

CODLING MOTH (*CYDIA POMONELLA* L.)

By A. M. MASSEE

Codling Moth has been very plentiful in Kentish orchards during the past three seasons, and every effort should be made to prevent this pest infesting the apple and pear fruitlets, and producing maggoty fruits, which fall prematurely.

Codling Moth causes most damage in this country in years when the crop is reduced through some cause, e.g. the frost years of 1935 and 1944. In those years many of the fruits that escaped the frost were destroyed by Codling Moth maggots. Reference to the East Malling Spray Calendar (1942 edition) indicates that the Codling Moth spray should be applied at the end of June. As pointed out, however, in the *East Malling Research Station Annual Report for 1943* (1944), page 114, in an early season the June lead arsenate on apples for Codling Moth control should be applied by the middle of the month instead of during the last week. The spray can then be put on with the Scab spray, if necessary in the second week of June, but since weak lime-sulphur with lead arsenate is now recognized as a damaging spray, colloidal or dispersible sulphur and *not lime-sulphur* should be the fungicide used.

In practice fruitgrowers should get "Codling-minded" during the third week of May. The moths are readily noted flying about, more particularly on warm, sunny and sultry evenings. They should be looked for around the pack house, on the trees adjoining the headlands, and especially on isolated trees of susceptible varieties.

The best spray to use is : 2 lbs. lead arsenate powder (or 4 lbs. paste) to 100 gallons water. No spreader is required. Every endeavour should be made to direct the spray on to the developing fruitlets, since most of the eggs are deposited on the fruit surface.

If some of the maggots have entered the fruitlets before the spray has been applied, they can be killed by adding 8 oz. nicotine to the lead spray. If nicotine is added, however, a spreader should be used.

However well the spraying is done, some of the Codling maggots will escape, and survive to carry on the infestation the following season. A further measure against Codling Moth is therefore worth while as a supplement to spraying. Sack bands (such as those used for Weevil traps) should be placed around the tree trunks, by the end of July. Two points must however, be borne in mind : (1) if the trees have been grease banded the sacking must be put on *below* the ring of grease. (2) The bands must be removed in November, and the cocoons in the sacking and those which remain attached to the bark should be destroyed. It is no use relying on a tar oil or petroleum wash to kill the maggots in the bands during the course of winter spraying operations. Sack banding is of little or no value if the trunks of the trees have very rough bark, because such bark provides adequate shelter for the hibernating larvae and they do not seek the shelter of the bands.

Many varieties of pear are subject to Codling Moth attack, and pear growers are advised to examine the pear fruitlets very carefully for the presence of the eggs. The Codling Moth larvae enter the pear fruits by way of the eye, while they usually enter the apple by the side.

Summary.—A commercial control of Codling Moth can be obtained by spraying during the latter part of June with a lead arsenate spray, or not later than the end of the second week of June in an early season. This applies to the fruitgrowing areas of the south-east and east of England.

The formula is as follows :

Lead arsenate powder (or paste 4 lbs.)	2 lbs.
Water	100 gallons.

Colloidal sulphur may be added for Scab.

"MERCURATED LEAD ARSENATE"—WHAT IS IT ? WHAT DOES IT DO ?*

By H. SHAW and M. H. MOORE

THE story of "Mercurated Lead Arsenate" began towards the end of 1940 when, at the suggestion of Mr. M. FitzGibbon of Messrs Lunevale Products Ltd., we started the systematic examination of a series of organo-mercurials as protective fungicides. Some of these compounds had been known for many years to be effective seed disinfectants, but practically nothing was known of their behaviour as foliage sprays. The only references found in the literature were two somewhat sketchy Danish contributions published in 1930 and 1932. These did little more than indicate that certain organo-mercurials of unstated composition could be applied with comparative safety to fruit trees in leaf, and that some control of Brown Rot Blossom Wilt may have resulted.

We were interested in these compounds in the first place because of the opportunity they offered of studying the connection between their chemical constitution and fungicidal action, but in addition we had in mind their possible use against Apple Scab. The prospect of successful use for this purpose was, however, not too rosy. The mercurials in general were known to be poisonous, many of them highly so, and farm spraying conditions do not lend themselves to elaborate safety precautions. Moreover, there was reason to expect that damage would follow their application to foliage ; even when used on seed grain considerable care is necessary if germination is not to be impaired. Then again, unless the mercurials were effective at a phenomenally low concentration, the cost would be prohibitive, to say nothing of an inexcusable waste of mercury. Further, even if the toxicity were high enough to permit, in theory, the use of an economically low concentration, the problem would arise in practice of distributing so small an amount adequately over the tree.

In spite of these possible objections the mercurials seemed to be worth trying, especially as laboratory testing methods were available that within a few days should give some indication of the fungicidal value. Tests were therefore made,† but a succession of technical difficulties was met with and the "few days" lengthened to several months before reliable results were obtained. But when they came, these results were most striking. By far the most powerful fungicide of the five substances tested was phenyl mercury chloride. A concentration of 0·001 per cent. (1 in 100,000) completely prevented the germination of Apple Scab spores, while 0·00005 per cent. (1 in 2,000,000) allowed only 50 per cent. to germinate. It was no less than one thousand times as toxic as ethyl mercury chloride, although the latter is generally accepted as the more effective of the two against seed-borne diseases. This result was particularly interesting because phenyl mercury chloride has advantages over the other compounds in several important respects : it is by far the least soluble in water and therefore the most suitable for use as a protective fungicide ; it is, for a mercurial, of exceptionally low toxicity to animals and consequently least dangerous to handle ; and it is the easiest to manufacture.

A preliminary field trial of phenyl mercury chloride (P.M.C. in this age of initials !) was clearly justified and, in the absence of any knowledge of its safety on foliage and fruit, six small Cox's apple trees were sprayed in 1941 with a sulphite-lye suspension of 0·01 per cent. P.M.C. (1 part in 10,000). Applications were made at the Green Cluster, Pink Bud, Petal Fall, and Fruitlet stages. A late frost eliminated the crop and the degree of Scab-control could therefore be estimated only on leaf infection. Nevertheless, a most striking result was evident, for close inspection of the trees late in June revealed only a single small Scab spot on one tree, although neighbouring unsprayed trees were freely infected. No sign of damage was noticed.

In 1942, P.M.C. had its first full scale intensive field trial when, again at 0·01 per cent. (about one and a half ounces per 100 gallons of spray) as a sulphite-lye suspension of the pure substance, it was compared with various sulphur sprays for Scab-control on seven-year-old bush Cox's on IX. A full programme of the usual four sprayings was carried through, and there was a good crop. Lime sulphur at 1 per cent. (each time) proved the best of the sulphur sprays, reducing leaf-infection to about one-sixth, and fruit-infection to about one-twelfth of that found on similar unsprayed trees in the trial, in spite of its being applied pre-blossom at less than usual commercial strength. There was, however, no Scab at all on the leaves of eight trees sprayed with P.M.C., and only a trace (one seventy-eighth of that on unsprayed trees) on the fruit. But even at this very low concentration the spray proved unsafe, for only about half a crop was set compared with that on unsprayed and lime sulphur sprayed trees. The reason for this is not yet clear and is being investigated ; it seems likely that P.M.C. may act on some of the unopen flowers to prevent setting, or it may cause dropping of

* Based on an address given to the Colchester Fruitgrowers' Discussion Group on 17th January, 1945.

† The laboratory work described was carried out by Dr. H. B. S. Montgomery and Dr. H. Shaw.

very tiny fruitlets. It was evident that the loss of crop was not due to fruit-drop of the kind that lime-sulphur causes, for all the dropped fruitlets that were big enough to handle were collected up and recorded. P.M.C. also caused an unusual kind of leaf damage, many leaves showing pale yellow areas associated with puckering and down-curling of the margins, and in addition there was leaf-drop so that the foliage appeared thin and straggly.

The first full trial had therefore confirmed that phenyl mercury chloride is powerfully fungicidal against Scab, but had shown it to be unsafe on these Cox's at 0·01 per cent. It has since been found, however, that the trees on this plot are potash deficient. Whether, and how far, this accounts for the damage caused by the 0·01 per cent. spray requires further investigation.

Meanwhile the manufacturers, considering the problem of making up a product suitable for field use, had suggested precipitating the fungicide on a carrier that would suspend well in water. A preparation* consisting of P.M.C. on china clay resulted, and was first included in the 1943 trial. Another on lead arsenate (" Mercurated Lead Arsenate ") was produced to give a combined fungicide-insecticide. In the early stages of these trials, however, it was necessary first to work out fully the behaviour of the fungicide alone, so the lead arsenate preparation was not then included.

The problem of finding a safe dilution that would still give satisfactory Scab-control was tackled in 1943 and 1944. Dilutions of the sulphite-lye suspension ranging from 0·01 per cent. to 0·00125 per cent. was tested in each year. The strongest spray (0·01 per cent.) again gave much better Scab-control than 1 per cent. lime-sulphur, but again it caused damage similar to that in 1942, so it seemed too strong for general commercial use.

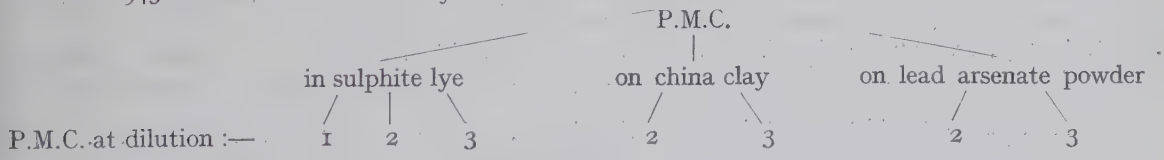
The next dilution (0·005 per cent., about three-quarters of an ounce per 100 gallons) proved very promising. It gave slightly better Scab-control than 1 per cent. lime-sulphur, though it was clearly less effective than the 0·01 per cent. dilution. But it *was* safe, for the fruit-set was as good as that on unsprayed or lime-sulphur sprayed trees. There was no leaf-drop, and only a trace of the pale areas on a few leaves here and there. It seemed, in fact, just right.

The next dilution (0·0025 per cent.) fell below 1 per cent. lime-sulphur in fungicidal value, and at the next again (0·00125 per cent., less than one-quarter ounce per 100 gallons) Scab-control was distinctly poor, and we had clearly got well below a desirable limit.

In the same two seasons, comparison was also made between two of the preparations of P.M.C. at the same strength (0·005 per cent.), and it was found that the china clay form was markedly less effective than the suspension in sulphite-lye. Fungicidal efficiency on china clay was, in fact, about equal to that of the next *lower* concentration in sulphite lye, i.e. 0·005 per cent. on china clay gave similar Scab-control to 0·0025 per cent. in sulphite-lye.

In the present year (1945), three forms of the material are being compared—the sulphite-lye suspension, the china-clay powder, and the " Mercurated Lead Arsenate " with which many growers are now familiar. In this last, P.M.C. is precipitated on to the ordinary lead arsenate powder (or paste) used for caterpillar-control, and the two together thus make a very convenient combined fungicide and insecticide. The manufactured product at present gives 0·0025 per cent. of P.M.C. in the spray when 2 lb. of the powder or 4 lb. of the paste is diluted in 100 gallons water—the usual strength for lead arsenate. This concentration is lower than the one we have found satisfactory in a sulphite-lye suspension, and is likely to be increased for future seasons.

The 1945 trial can be set out briefly thus :—



Dilution 1 is 0·01 per cent. P.M.C., 2 is 0·005 per cent., and 3, 0·0025 per cent.

Some results on Scab-control on foliage have already come to hand, and they amply confirm all the findings of the previous trials, with the addition of information on the performance of " Mercurated Lead Arsenate ". At the same strength, there was very little difference between it and the sulphite-lye suspension—if anything the latter was slightly more effective. The china clay preparation was again inferior.

A commercial trial on established Cox's is also in progress this year. Lime-sulphur at commercial strengths (as in the E.M.R.S. Spray Calendar) is being compared—in sequence at Green Cluster, Pink Bud, and Petal Fall—with P.M.C. at 0·005 per cent. in sulphite lye, and at 0·005 per cent. and 0·0025 per cent. as " Mercurated Lead Arsenate ". Up to the present (July), records made on dropped fruitlets (June Drop) have shown that lime-sulphur has permitted very little Scab-infection, being

* Now available in a modified form under the name " Venturicide ".

superior in this respect to " Mercurated Lead Arsenate " at either strength and, though less so, to the sulphite-lye suspension.

The promise of P.M.C. for Scab-control has thus been demonstrated, but it is doubtful whether it will control Red Spider and most improbable that it will control Apple Mildew. Moreover, it must be borne in mind that in most of the experimental comparisons with lime-sulphur, that fungicide was applied at 1 per cent. before as well as after blossom, and P.M.C. at 0·005 per cent. on lead arsenate gave roughly the same, and in sulphite lye, rather better Scab-control. It still, in fact, remains to be seen whether a P.M.C. preparation can satisfactorily replace a full schedule of sulphur sprays in the season's spray programme, though it should prove to be a useful addition to the materials already available for solving certain problems, especially, perhaps, as regards spray damage. Prominent among these is the desire for a combined Codling Moth-Scab spray in mid-summer, when weak lime sulphur must not be used with lead arsenate.

Summary.—The development of the combined fungicide-insecticide known as " Mercurated Lead Arsenate " is traced from earlier investigations of the fungicidal properties of phenyl mercury chloride, the pure substance on which that preparation is based. Field trials showed phenyl mercury chloride at 0·005 per cent. to be approximately as effective as lime-sulphur at 1 per cent.; results differed according to the form of preparation. At 0·01 per cent., Apple Scab-control was improved, but damage resulted.

THREE IMPORTANT HOP DISEASES*

By W. G. KEYWORTH

Some twenty distinct diseases of hops have been recognized, most of which are infectious and caused by fungi, bacteria or viruses. Five of these are of general concern, and their control is of considerable importance. They are the fungus diseases Mildew (Mould), Downy Mildew and Verticillium Wilt, and the virus diseases Nettlehead and Mosaic. Mildew and Downy Mildew can be adequately treated by routine spraying methods, and their control presents no great difficulty to the grower. Verticillium Wilt, Nettlehead and Mosaic, however, being caused by internal parasites, cannot be treated by such methods. All three diseases have been known for over twenty years, during which time they have become of increasing importance and now constitute a major problem to the industry.

To meet the situation special investigations were started in 1938.† Although there are still many gaps in our knowledge, this work has reached a stage where it is possible to assess the relative significance of each of these diseases and to show what steps must be taken if they are to be dealt with effectively.

Verticillium Wilt.—*The Fluctuating type.*—The most striking fact recently discovered is that, contrary to previous ideas, the mild form of this soil disease is very widely distributed. This mild form, known as the Fluctuating Type because of the variation in Wilt intensity from year to year, has been reported from Kent, Sussex, Herefordshire, and Worcestershire. In certification inspections by the Ministry for instance, some growers have learned that their gardens which they previously believed to be healthy, actually contain well-established outbreaks. In other gardens one or two infected hills only have been seen.

Naturally, growers are disturbed as to the significance of these very widely scattered outbreaks and fear some wholesale attack on the crop. It may be said at once, however, that no such danger exists.

Let us consider the history of this form of the disease. It was first discovered by Dr. R. V. Harris in 1924, in a hop garden at Penshurst, Kent. Observations in this garden since that time have shown that the total effect on the crop has been almost negligible. True, in some wet seasons, a fair number of bines have wilted and died, but the hills have usually recovered the following season, and the original garden is still in practically full production. In other gardens no wilting has been seen at all. The only visible symptoms in these gardens are coarse, thickened bines on scattered hills, such bines containing the brown wood indicative of the presence of the fungus *Verticillium*. Some of these outbreaks have been traced to previous potato crops—also susceptible to *Verticillium* attack; others have been started by the planting of infected sets; and many are obviously of such long standing that their history is unknown. In fact, it now seems certain that this form of Verticillium Wilt existed in hops long before its discovery in 1924.

* Reprinted from *Agriculture*, the Journal of the Ministry of Agriculture, March, 1945, Vol. LI, No. 12, pp. 556-61.

† Now being undertaken jointly with the Long Ashton Research Station and the South-Eastern Agricultural College, Wye, Kent.

The Progressive type.—So much for the mild form ; but what of the reports of widespread devastation caused by this disease in some areas ? Here we are dealing with a really dangerous and quite distinct form of the disease known as the Progressive Type.

The most important feature of this form is that infected hills do not recover and, moreover, as the fungus contaminates the soil, replanting is useless and the affected area becomes derelict. Symptoms appear early in the season and are of a very severe nature. The leaves wilt and die and then fall from the bines, leaving them bare and blackened. (Fig. 1.) Starting often from one infected

Verticillium Wilt in South-east England.

hill, the disease advances through the garden, which may become completely useless in some four or five years. As infection can be spread by the blowing about of the dead leaves, as well as in cultivation, the disease constitutes a danger not only to the one farm but also to others nearby.

The history of outbreaks of this type is particularly significant. The first one to be seen occurred on a farm near Paddock Wood in 1933, having then been in existence for one or two years. In 1934 it was discovered on five other farms in the same neighbourhood. Since that time it has more or less ruined these farms and also spread to some fifty others within a radius of about ten miles.

The map illustrates the present position in the South-east. Both fluctuating and progressive outbreaks are shown, and although our information on their distribution is still incomplete it is clear that the fluctuating outbreaks are spread over a wide area. The progressive outbreaks, on the other hand, are, with one or two exceptions, fairly closely aggregated around the original centre near Paddock Wood.

It is in this at present comparatively limited area that the greatest danger from Verticillium Wilt exists. Here, all growers and their workers should be on the alert for the early signs of the disease. If progressive outbreaks are reported in their very early stages, drastic measures will greatly lessen the danger of spread, but if left too long the disease may become uncontrollable.

If outbreaks do occur it is essential that the diseased hills should be removed promptly so as to lessen the danger to neighbouring farms.

What of other districts? Here the use of Wilt-free planting material should solve the problem. If growers will use only cuttings and sets taken from healthy gardens the danger of spread to new areas is very small indeed. Where this precaution is not taken, however, there will always be a danger that new centres of Progressive Wilt will be established, with consequences that may be grave. This precaution applies also to the fluctuating type of the disease. No matter how innocuous this type may appear at present, it is nevertheless a form of Verticillium Wilt and as such may be related to the progressive type. This point is still being investigated, but meanwhile all growers should avoid planting material from gardens showing even the smallest traces of either form of the disease.

The Ministry's scheme for certifying Wilt-free gardens provides an excellent means to this end. The inspections carried out under this scheme are of a most searching character, and growers can be

FIG. 1.
Portion of hop garden severely attacked by Progressive Wilt.

confident that cuttings from certified gardens constitute the best source of Wilt-free stock at present commercially available.

It is clear that the Progressive Wilt can be kept within bounds and perhaps eventually eradicated, provided strict precautions are taken. The expansion and development of the certification scheme will also help to prevent the further spread of either form of the disease. In addition, research has given a new hope that even the badly affected farms may eventually be brought back into production by the use of resistant varieties. Studies have been made on the Wye Seedling varieties during the past four years, and some five or six of these have proved to be fairly resistant, even under the most severe tests.

The Virus Diseases.—Largely because of the alarming nature of recent outbreaks of Wilt, the dangers of the less spectacular but much more widespread diseases, Nettlehead and Mosaic, have often been neglected. These diseases occur in all hop-growing areas. Nettlehead, although most prevalent in Fuggle, attacks all varieties of hop, but Mosaic only affects Goldings and is thus of greatest importance where these are widely grown, i.e. in Worcestershire and East Kent.

Nettlehead.—It is not known how long Nettlehead has existed in the hop gardens of this country. First described in 1897, it was undoubtedly present long before that time and has been gradually increasing in importance year by year.

It is an insidious disease. Once infected, the hill becomes permeated with the virus and will ever recover, although it may live for several years, gradually declining in vigour and constantly erving as a centre of infection. The intensity of the disease varies greatly with weather conditions. n cool seasons a hill may appear very badly diseased but, as more often happens, if the temperature ises greatly in the summer, the symptoms become " masked " and only reappear with the onset of ooler conditions. This makes efficient roguing very difficult. Some growers start to remove infected ills very early in the season before the bines are trained, and this is undoubtedly the best plan, as uch hills can then be picked out by their weak, stiff bines and *up-curled* leaves. Too often, however

FIG. 2.
Hop plant affected with Nettlehead.

FIG. 3.
Mosaic disease on upper portion of bine, showing down-curled leaves and dead tip.

this opportunity is missed and the hill is left for grubbing after hop picking or sometimes overlooked completely. A severely affected plant is shown in Fig. 2. Reduction in crop may not be very great in the first year of infection, but the cumulative and widespread losses from this disease render it the greatest single cause of loss to the hop industry as a whole.

As with all such troubles prompt action will usually prevent much damage, but the measures taken must be ruthless. In young gardens not only must the obviously infected hills be removed but also those showing only slight symptoms; and as an added precaution in small outbreaks, all hills adjoining those diseased should come out too.

Sometimes, however, the grower is presented with an almost insoluble problem. Like all virus diseases, Nettlehead can be carried in the planting stock. It thus often happens that the grower, when planting a new garden, unsuspectingly scatters the disease throughout it in the sets. The only

real cure for such a situation s to take the initial precaution of planting stock of known health. Unfortunately so many growers have now come to regard this disease as a more or less " necessary evil " that, not only do they tolerate it in their own gardens, but often sell it to others and thus add their quota to the gradual " deterioration " of the stock.

So widespread is this disease that it is becoming difficult to find any gardens completely free from it. In the Ministry's certification scheme, however, a limit of a very low percentage of virus infection has been fixed, and growers who buy certified material will thus be assured of a source of planting stock at least reasonably free from Nettlehead.

There are still big gaps in our knowledge of the disease. It is not known, for instance, how it is transmitted in Nature, although by analogy with similar troubles insects are suspected to be the agents. Again, soil factors, at present obscure, appear to have some relation to the occurrence of the disease. Research has so far failed to show that the virus can actually remain active in the soil and therefore replanting is practicable.

All these points are being investigated. In the meantime, however, growers can do much to help themselves and their neighbours by planting only the healthiest stock and by promptly roguing infected hills when they appear.

Mosaic.—Mosaic is a lethal disease and thus in some respects presents a more straightforward problem. The first symptom is a curling *downwards* of the leaves, followed by the stopping of growth of the bines and their death backwards from the tips. (Fig. 3.) The hill becomes rotted and dies in one or two years. Infected hills can thus be fairly readily detected and removed.

One outstanding feature of this disease is the existence of " carriers ". Certain varieties of hop can carry the virus within the plant without showing symptoms. The disease can, however, readily spread from such plants to other hops. The most important carrier varieties are Fuggle and the Wye Seedlings. While these hops have the great advantage that they do not succumb to Mosaic themselves, they should always be grown at some distance from Goldings, which otherwise may contract serious and apparently inexplicable outbreaks of Mosaic.

It has recently been found that some male hops also behave in this way, and several outbreaks have been traced to the presence of carrier male plants. Research is now in progress to classify males in this respect and to propagate those suitable for growing with different varieties of hops.

Mosaic virus persists in the cuttings and sets from infected hills, and the remarks made about Nettlehead in this respect apply with equal force to this disease.

Conclusions.—In order to combat these three diseases certain well-defined lines of action must be followed.

(*a*) The further spread of all three can be checked by commonsense precautions about planting stock, and everyone is urged to take full advantage of the Ministry's Certification Scheme. Any grower with a really healthy garden can help considerably by entering it for certification.

(*b*) Growers in the Weald of Kent should always be on the alert for the occurrence of new outbreaks of Verticillium Wilt and report them immediately to the East Malling Research Station ; growers elsewhere should make every effort to see that this disease is not introduced into their farms.

(*c*) Nettlehead demands greater vigilance than has been practised hitherto, both when starting new gardens and when roguing old ones.

(*d*) Mosaic disease, so great a problem to Golding growers, can be reduced both by roguing and by attention to the proper segregation of varieties.

All these measures demand extra care, but all are eminently practicable, and there is no reason why growers should not in future be increasingly assured of really healthy hop farms.

Summary.—The three hop diseases Verticillium Wilt, Nettlehead and Mosaic are briefly described and their economic importance to the hop industry compared. Verticillium Wilt occurs in two forms—a widespread mild fluctuating form, and a comparatively localized very severe progressive form. The latter form of the disease has apparently spread from an outbreak seen in 1933, near Paddock Wood, Kent, and by 1944 had been reported from about fifty farms in that locality. The virus diseases Nettlehead and Mosaic occur in all hop areas, the former mainly in the Fuggle variety, and the latter in Goldings. These diseases cause a considerable annual loss of crop. Suggestions for action by growers are given, in particular the use of the Ministry of Agriculture Certification Scheme for hop cuttings.

INDEX

Abnormal lignification, 36, 108
———— ripening of cherries, 25
Abcission Process, 24
Acid cherry rootstocks, 17
Alcoholic potash as solvent for aphis eggs, 29
Alpha-naphthalene acetic acid, use of, on apples, 24, 118
Amateur's Fruit Garden, 22
Aphides, on apples, 82
Apple Aphis, 29
——— ———, modifications of procedure with eggs, 30
——— Blossom Weevil, 28, 30, 83
——— ——— ———, control experiments, 23, 28, 30, 88
——— breeding, 19
——— Canker, 26
——— Capsid Bug, 28, 30, 82
——— Codling Moth, 16, 30, 79
——— ——— ———, control, 127
——— Fruit Rhynchitis, 78
——— Leaf Scorch, 19, 25, 64
——— mineral content of leaves, 25
——— plantations, cropping history, 22
——— root cuttings, 18, 100
——— rootstocks, 17, 73, 98, 106
——— ————, anatomy of, 17, 107
——— ————, experiment in the control of Crown Gall, 73
——— ————, immune from Woolly Aphis, 17, 23
——— ————, in relation to mineral composition, 25
——— ————, new varieties, 17
——— ————, propagation, 13, 18, 98
——— Sawfly, 30
——— ———, control by D.D.T., 30
——— Scab, 26
——— ———, control by phenyl mercury chloride, 30, 128
——— ———, ———— mercurated lead arsenate, 128
——— ———, ———— sulphur sprays, 28
——— ———, methods of measuring infection, 26
——— seedlings, 19
———, sprays to prevent pre-harvest drop, 24, 118
———, varieties in Bradbourne gardens, 117
———, Woolly aphis, parasite of, 28, 29
Apples, acreage and cropping, 13
———, Black rot caused by *Monilia cinerea*, 75
———, breeding experiments, 20
———, control of Brown Rot, 124
———, cordon culture, 17, 33
———, die-back due to mineral deficiency, 64
———, injection experiments, 65
———, ———— to cure deficiencies, 65, 119
———, new cultural trials, 17
Apricot, varieties in Bradbourne gardens, 19, 117
Apricots, rootstocks for, 101

Bacterial canker, 16, 22
———— ————, cherry varieties resistant to, 106
Bacteriosis of plum and cherry trees, 26
Beans, mineral deficiencies in, 50
Beetles, Heteromerus, on plums, 78, 79
Benzene hexachloride (666) as an insecticide, 30
Biennial bearing, 19
Black Apple Rot, 75
Black-bodied Sawfly, 80
Black Currant Leaf-curling Midge, 29
——— ——— Reversion, 29
Black Currants, cultural and manurial trials, 21
——— ———, propagation, 14
——— ———, pruning trial, 21
——— ———, seedlings, 21
——— ———, variety trials, 20
Black Dot foot rot in tomatoes, 38
Bordeaux mixture for control of Bacterial Canker, 16, 26
Boron deficiency, 50
Bradbourne, lake bed, 55, 67, 70
————, walled gardens, 115
Breeding, 19, 21
Bridging incompatible combinations of pear and quince, 21
Brown Rot, of apples, control in commercial orchards, 124
——— ——— fungus causing Nut Drop, 27
Bud-rubbing, 19

Calcium deficiency, 46, 50
Cane nurseries, for raspberries, 21, 27, 109
Carrots, field trial to control mineral deficiency, 54
Cereals, acreage and cropping, 15
———, experiments for control of mineral deficiency, 48, 51
———, seed soaking for nutrient supply, 58
———, Tarsonemid Mite of, 83
Cherries, abnormal ripening, 25
———, cropping, 13
———, high- and low-worked trees in relation to Bacterial Canker, 17, 22
———, trace element deficiencies, 57, 60
———, varieties and classification, 19
Cherry Bacterial Canker, 16, 105
——— Black Fly, 82
——— orchard planning, 104
——— pollination, 104
——— rootstocks, 17, 103
——— Scab, 28
——— Slugworm, 80
——— varieties resistant to Bacterial Canker, 106
Chlorophenols as ovicides, 30
Chlorosis, 65
Chocolate Spot disease of beans, 50
Clay Coloured Weevil, 79
Codling Moth, 16, 79
——— ———, control measures, 127
Cordon culture of apples, 17, 33
Cover cropping, 18, 21
Cover crops, spray damage on, 19
Crop recording, 23
Crown gall, 73
Curative experiments for mineral deficiencies, 48
Currant aphides, 29
Cuttings, propagation from, 18, 23
Cylindrocladium Shoot Wilt, 27

D.D.T. field trials, 28, 30
——— laboratory tests, 28
Deficiencies, boron, 50
————, calcium, 46, 50
————, combined potassium and trace element, 25, 57, 64
————, iron, 50, 72, 119
————, magnesium, 19, 25, 46, 50
————, manganese, 18, 24, 25, 51, 60, 67, 70, 119
————, multiple, 61, 64
————, potassium, 25, 50, 57
————, phosphorus, 48, 50, 58
————, zinc, 50

Devon, derelict lands, 46
———, The Red Soils, 49
Dieback, 64
D.N.C.—petroleum wash as insecticide, 16, 30
Dosage Table, for solid injections, 122
Double-working pear and quince, 18, 21, 22

Experimental design, 23
———— gassing machine, 28
———— nurseries, 13
———— orchards, 13, 23
———— pear plantations, cropping of, 23

Fertilizers, inorganic, 19
Flea Beetle, on apple, 78
Frost Damage, 13
Frost Damage Investigations, 19
——— ——— prevention, 21
Frost-resistant varieties, 13, 20, 117
Fruit drop, pre-harvest, 24, 118
——— gardens, for amateurs, 22
Fungicides, field trials, 26, 30, 128
————, laboratory tests, 30

Gassing machine, for nicotine vaporizing, 28
Gooseberry aphides, 29
Ground Beetle, eating stored apples, 79
Growth substance, 18, 23, 24
——— ————, compatibility with Insecticides and Fungicides, 24
——— ————, spray to control pre-harvest fruit drop, 24, 118
——— substances, on plum rootstock layer beds, 34
Guesarol, 30

Histological Investigations, 17, 107
Heteromerus Beetles, on plum, 78, 79
Hop Aphis, 16
—— Canker, 31
—— Downy Mildew, 16
—— Eelworm, 32
—— Mosaic, 31, 134
—— Nettlehead, 31, 132
—— Phytophthora Root Rot, 31
—— Red Spider, 16, 82
—— —— ———, control measures, 126
—— Shy Bug, 32
—— Verticillium Wilt, 31, 130
—— virus diseases, 31, 132
Hops, acreage and cropping, 15
———, brewing tests, 30, 32
———, commercial varieties, 30, 32
———, comparison of strap cuts and natural runners, 31
———, cultural trials, 31, 92
———, distance of planting, 31, 92
———, dressing, 31
———, manurial trials, 31
———, Ministry's Certification Scheme, 32, 132
———, new varieties, 30, 32
———, pulling, 31, 92
———, propagation, 31, 32
———, Preservative Value (P.V.), 15, 23, 30, 32
———, valuation, 15
Hormones, 118

Identification keys, for rootstocks, 17
———— —— —— strawberries, 20
Inarching, 17, 25
Incompatibility, of pear on quince, 18
Indicator plants, for mineral deficiencies, 24, 44, 70
Injection, for cure of mineral deficiencies, 65, 119
———, for diagnosis of mineral deficiencies, 24, 44
———, of potato tubers with nutrients, 57
———, against Silver Leaf, 26
Insecticides, 30

Iron deficiency, 25, 50, 56, 61, 72, 119
Irrigation, 21

Late-blossoming varieties, 19, 20, 117
Layers, treatment with growth substances, 34
Layering, 18
Layer beds, rooting in, 23
—— ——, wilting of plum and cherry shoots, 18, 26
Leaf painting, for diagnosis of deficiencies, 25, 67
Lime-sulphur, 16, 123, 126, 128
Loganberries, 20
————, manurial trial with, 21
————, methods of training, 21
————, propagation of, 14
Loganberry Cane Spot, 21, 27
Lonchocarpus, 16, 30

Magnesium deficiency, 19, 25, 46, 50
Manganese deficiency, 18, 24, 25, 50, 60, 61, 67, 70, 119
———— ————, spraying for control of, 24, 51, 56, 60, 67, 122
Mangolds, field trials to control deficiencies, 54, 55, 67
Marshlands of Kent, 50
Marsh Spot disease of peas, 52
Mercurated lead arsenate, 128
Meteorology, 21, 43
Mineral deficiencies, 18, 19, 24, 25, 43, 60, 64, 67, 70, 119
Morello cherry scab, 28
Mosaic disease of hops, 134
———— ———— raspberries, 110
Multiple deficiencies, 61

Nectarines, rootstocks for, 101
Nettlehead, virus disease of hops, 132
Nicotine, as insecticide, 127
———, vaporized, against Strawberry Aphis, 28
Nitrophenols as ovicides, 29
Northern Winter Moth, 79
Nut Drop of Cobnuts, 27
—— Leaf Sawfly, 80

Oats, field trials to control mineral deficiencies, 48, 72
Organo-mercurials as fungicides, 30, 128
Ovicides, laboratory tests, 29
———, technique of laboratory testing, 29

Papery Bark Canker, 27
Pastures, effect of limestone dust on, 48
Peach aphid, 82
———, varieties in Bradbourne gardens, 117
Peaches, rootstocks for, 101
Pear and cherry slugworm, 80
—— plantations, experimental, 13, 32
—— rootstocks, 101
—— varieties in Bradbourne gardens, 117
—— Sucker, 81
Pears, acreage and cropping, 13
——, double-working, 18
——, mineral deficiencies in, 65
——, rootstocks for, 100
Peas, field trials to control mineral deficiencies, 52
Phenyl mercury chloride for Apple Scab control, 30, 128
Phosphorus deficiency, 48, 50, 58
Phytophthora Root Rot of Hops, 31
Plant analysis methods, 24, 44
—— injection for cure of deficiencies, 65, 119
—— ———— for diagnosis of deficiencies, 24, 44
Planting Problems, a survey, 96
Plum Bacteriosis, 26
—— Leaf Sawfly, 81
—— rootstocks, 101
—— ————, wilting of shoots, 18, 26

Plum rootstocks, treatment of layers with growth substances, 34
—— Sawfly, 30
—— Verticillium Wilt, 27
—— Weevil, 77
Plums, cropping, 13
——, mineral deficiencies in, 65
Pollen, influence on fruit size and drop, 22
Pollination of cherries, 104
Potassium deficiency, 25, 50, 57
———— ————, combined with other deficiencies, 64
Potatoes, acreage and cropping, 14
———— effect of manganese deficiency on yield, 71
———— effect of straw application, 14
———— field trials to control mineral deficiencies, 24, 46, 53
————, tuber injection, 57
Predaceous Hemipteron, on apple and plum, 81
Pre-harvest fruit drop, spraying for, 24, 118
Propagation, 18, 20, 21, 23, 34, 98
Pruning, 19, 21
————, in relation to biennial bearing, 19
————, summer, on cordon apples, 33

Quince rootstocks for pears, 18, 100

Raspberries, breeding, 21
————————, propagation, 14, 21, 109
————————, seedlings, 14, 20
————————, varieties, 20
Raspberry Beetle, 16, 30
———————— Cane Blight, 16, 110
———————— —— Nurseries, 21, 27
———————— —— ————, planting and maintenance, 109
———————— —— Spot, 27, 110
———————— Diseases investigations in Scotland, 26
———————— Insect vectors of virus diseases, 26
————————, Ministry Certification Scheme, 26, 110
———————— virus diseases, 26, 109
Red Spider, on fruit trees, 28
—— ————, on hops, 16, 82, 126
—— ————, field spraying trials, 23, 28, 30
—— ————, predaceous insects of, 28
—— Spiders, British, 29
Root and green crops, acreage, 14
Rootstock effect on mineral content of leaves, 25
Rootstocks, anatomical studies, 17, 107
———————— for tree fruits, 17, 98
————————, identification keys for, 17
————————, new varieties, 17
" Rubbery Wood " in Apples, 18, 36
———— ————, staining as a means of detection, 108

Sampling, 22
———— apple blossom weevil counts, 91
Seed soaking, of cereals with nutrients, 58
Seeds hay, 15
Shy Bug, 32
Silver Leaf, injection against, 26
—— ——, in relation to Papery Bark Canker, 27
Size of fruit, estimation by sampling, 23
Slugworm, pear and cherry, 80
Soil moisture tensiometers, 19
Spray application, influence of personal factor, 23, 26
—— damage on cover crops, 19
Spraying in bloom against Apple Scab, 26
———— Programme, 15
———— to cure mineral deficiencies, 51, 56, 60, 72, 122
———— to reduce pre-harvest fruit drop, 24, 118
Stoolbeds, 13, 18
Straw, application on black currants, 21
———— ———— — potatoes, 14
Strawing for frost damage prevention, 21
Strawberries, breeding, 21
————————, certification, 20, 113
————————, cropping trials, 20
————————, daughter nurseries, 14
————————, prevention of frost damage to, 21
————————, propagation, 14, 20, 113
Strawberry Aphid Survey, 28
———————— ——, vaporized nicotine treatment, 28
———————— Identification Key, 20
———————— insects, 28
———————— irrigation trial, 21
———————— Leaf Blotch, 27, 76
———————— nuclear stocks scheme, 20, 113
———————— runners, production of, 14, 20, 113
———————— ————, certificates, 20, 113
———————— Tarsonemid Mite, 29
———————— Verticillium Wilt, 27
———————— virus diseases, 27, 113

Tar distillates as ovicides, 30
Tarsonemid Mite of Cereals, 29, 83
———————— —— — Strawberry, 29
Thiuram sulphides, 30
Trace element deficiencies, 24, 25, 43, 60, 64, 67, 70, 119
Tomatoes, cropping, 14
————, diseases in variety trial, 38
————, trials in 1944, 38
Tuber injection of potatoes, 57

Variation studies, 22
Verticillium Wilt, 15, 23, 27, 31, 130

Walnuts, 21
Weather conditions during 1944, 41, 43
Wheat, mineral deficiencies in, 50, 51
Winter Moths, 29
Woolly Aphis, parasite of, 28
———— ——, rootstocks immune from, 17

Zinc deficiency, 50, 61

Sheds, 43
Silo, 43, 52
Silver Spot, 52
Silver sand, injection method, 40
——— in lands contaminated by sulphur, 43
Site of lands contaminated by sulphur, 43
Slime, 31
Soil analysis, 5, 6
Spray, 43
——— for potato diseases, 43
Spraying in March to check Apple Scab, 45
——— to control Potato diseases, 43, 44
——— to prevent Potato diseases, 43, 44
Sterilisation, 43, 48
Stewart, Professor, 43
Storage for seed potatoes, 43
Strawberry, 43
——— , Alpine, 43
——— , Hautbois, 43
——— , Virginian, 43
——— , wood, 43
Sulphur, 43
——— , burning in Fig, 43
——— , dusting with, 43
——— , injection of, 43
——— , precautions against, 43
——— , spraying with, 43
Sunflower, 43
Swede, 43
Sweet Chestnut, 43
——— Pea, 43
Sycamore, 43
Syringa, 43